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PAPERS READ BY TITLE

THE PACIFIC OAK TWIG-GIRDLER¹

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ECONOMIC IMPORTANCE

One of the most important and characteristic native shade trees of the coast valleys of California is the California live oak (*Quercus agrifolia* Nec). As a general rule this fine tree is in a healthy and vigorous condition, but sometimes it is attacked by various insects, which give it a ragged and unsightly appearance. One of the most important of these insects is the twig-girdler. Both small and large trees sometimes are thickly spotted with small areas of fading, yellow, red or brownish foliage which stands out strikingly against the normal green of the healthy leaves. In the majority of cases the dead twig or small branch bearing the coloring leaves will show at its base the characteristic spirally-winding mine of the twig-girdler. Sometimes so many twigs and small branches are killed by the girdler that the tree dies. In any case, the ragged appearance caused by numbers of dead and dying twigs seriously injures the tree for ornamental purposes.

HISTORY AND IDENTITY

The species was described by Dr. George H. Horn in 1891, with host plant unknown. (Trans. Amer. Ent. Soc., Vol. XVIII, p. 298.)

¹ *Agilus angelius* Horn, family Buprestidæ, order Coleoptera.

Doane mentioned the work on the live oak in 1912 without naming the species. (Jour. Econ. Ent., Vol. 5, p. 347.) Childs, in 1914, gave a very good account of the insect and its work under the name of *Agrilus politus* Say. (Month. Bul. Cal. State Com. Hort., Vol. III, pp. 150-5.) He also figured the insect and its work and recommended methods of control. Essig, in 1915, figured the insect and gave a short account of the life history, work, distribution, food plants, control and natural enemies under the name *Agrilus politus*. (Injurious and Beneficial Insects of California, p. 234.) In January, 1917, Burke figured the eggs as those of *Agrilus angelicus* (U. S. Dept. Agric., Bul. 437, fig. I, Pl. IX) and in June of the same year gave a short account of the species under the same name. (Jour. Econ. Ent., Vol. 10, p. 330.)

Specimens have been sent to the leading specialists on the genus *Agrilus* and there seems no doubt but that the species is *angelicus* Horn. It is quite distinct from *politus* Say. A very similar species which has been identified as *angelicus* by some of the specialists lives in the manzanita (*Arctostaphylos* species) and the madrone (*Arbutus menziesii*) in the Sierras and coast valleys of Central California. There are some differences in the life history which cause the writer to believe that it is distinct. Experiments are now being carried on which should settle this point.

DISTRIBUTION AND FOOD PLANTS

The specimens from which the species was named came from near Los Angeles and from the Santa Cruz Mountains, California. Childs obtained his specimens at Palo Alto from the live oak. Essig says that the insect is found throughout the state of California, that the favorite host is the willow, that the live oak often is severely damaged by its attacks and that other food plants are the buckeye and hazelnut. He undoubtedly used the distribution and food plants of *A. politus*, under which name he accounts for the species.

The writer has reared specimens of the beetle from live oak twigs collected at Pasadena by Dr. A. G. Smith, and at Palo Alto, Los Gatos, Laurel and near Saratoga, Calif., by himself. Larvæ and the characteristic work have been found at Boulder Creek, San Juan, Monterey, Carmel, Woodside, Niles, Alum Rock, Napa and Mt. St. Helena, by Mr. R. D. Hartman. Mr. F. B. Herbert found the work very common at Montecito near Santa Barbara and at South Pasadena. During the past summer heavy infestations were found in the black oak and canyon live oak near Confidence, Tuolumne County, in the middle Sierras.

The following host plants have been determined: California live oak (*Q. agrifolia*), interior live oak (*Q. wislizeni*), leather oak (*Q.*

durata), canyon live oak (*Q. chrysolepis*), engelmann or mesa oak (*Q. engelmanni*), California black oak (*Q. californica*) and the tan oak (*Q. densiflora*).

The species range from a few feet above sea level to an altitude of 6,000 feet.

CHARACTERISTIC WORK

The first indication of an attack by the twig-girdler is scattering small patches of fading foliage. Other insects and diseases cause somewhat similar dying branches, but the trained eye usually can detect the difference. Roundheaded borers kill larger branches and their work is not so common, scales of the genus *Kermes* and some of the gall wasps kill smaller twigs, and a disease supposed to be related to the chestnut blight kills large patches of foliage on adjoining branches. Childs says that the foliage that dies from the girdler work is a light straw color when dry, while that killed by the disease is a distinctive reddish brown tinge. These color differences may hold true in some cases, especially during the first year, but the girdler work of the second year is apt to cause good sized patches of reddish foliage which are difficult to distinguish from the disease work.

A close examination of the dying or dead twigs will always show the real cause of the trouble. If it is the girdler there will be a small mine winding around under the bark and down the twig. During the first year this only goes a few inches, but during the second it may go for a foot or more, sometimes two feet, the mine spiralling the branch and killing all of the twigs terminal to it. It may go down one fork and up another. The foliage on the killed twigs will vary from a fading green to a reddish brown, depending on the time of the year each was killed. Usually most of the mine is just under the bark, but it may go into the wood. It usually spirals around the branch from four to twelve times, but sometimes runs straight down for a long distance. Just before it is completed the mine usually reverses and runs back up the branch for an inch or more, where it goes into the wood and terminates in the slightly enlarged pupal cell. After the beetle emerges the pupal cell opens on the surface of the branch in the oval emergence hole. Most of the branches killed by the girdler are not over one half an inch in diameter. The leaves fall before the end of the second year and the work shows as a leafless branch, an unsightly blemish on a splendid object of natural beauty.

THE TWIG-GIRDLER

The twig-girdler is a slender, whitish flattened boring grub of the common agriloid type. It varies in length from 1 mm. when newly hatched to 18 mm. when full grown. The mouth parts and tail for-

ceps are dark brown or black. Hatching from the egg during June and July, the girdler starts mining through the bottom of the shell and under the bark. By the middle of the first winter it has grown to be 7 mm. long and has extended its mine down the small twigs for from one to three inches. Most of the twigs have been spiralled and the foliage has faded to yellow. At this time some of the girdlers are under the bark and some have gone into the wood. Mining is continued during the succeeding spring and summer until the second winter, when the girdler has mined down the branch for about 6 to 12 inches and has grown to about 15 mm. long. Most of the foliage is reddish brown or rusty looking. The girdler now goes into the wood and lies outstretched in the center of the branch for most of the winter. In the spring it continues down the branch under the bark for an inch or more and then turns and retreats back up for several inches before it again enters the wood and forms the pupal cell. In the Santa Clara Valley this takes place about the middle of May. The girdler is now full grown and it soon shortens up to about half its former length and gets ready to pupate. The pupal cell is usually formed at an angle to the surface of the branch, the mine entering the wood and angling up to the surface for the emergence of the beetle.

THE PUPA. The pupa when first formed is a delicate whitish object with the head, body, wings and legs faintly indicated. It is about 7 to 9 mm. long and 1 to 2 mm. broad. The eyes soon commence to darken and in about two weeks all of the head, thorax and underside of the body have changed to a brownish bronze. The wings and elytra, which are folded on the breast and the dorsal surface of the abdomen, remain white. Upon the transformation of the pupa to the beetle which now takes place the wings and elytra change to the back and the elytra soon take on the normal bronze color of maturity. This is done without going through the interesting color changes of some of the other species like *politus*. Most of the pupæ were found in the field during the last of May and the first of June. Some have been found in April.

THE BEETLE. The beetle is a slender brownish bronze insect with a coppery or slightly golden thorax. Its length is from 5 to 7 mm. and its breadth from $1\frac{1}{2}$ to 2 mm. The males have dark green faces and the females brownish bronze ones. The claws are cleft in such a manner that the lower portion is turned inward and the hind tarsi; are stout and obviously shorter than the tibiæ. The newly formed beetle stays in the pupal cell for several days before it eats its way to the outer world. After this emergence, which takes place during May and June, the beetles fly around in the warm sun, feed on the edges of the leaves of the oaks and mate. Soon after mating the female lays

her eggs and both soon die. So far as could be determined, most of the beetles live about two weeks.

THE EGG. When first laid the egg is a dull white, flattened oval scale-like object $1\frac{1}{2}$ mm. long and $\frac{3}{4}$ mm. broad. It soon becomes darker with age and development and in from 4 to 5 days turns a shiny black. It is covered with a varnish-like covering which catches the dust, etc., so that in a week or more it looks like the brownish or blackish gray bark of the twigs. The egg is laid singly on the bark of the twig, near the end of the last year's growth. It is not tucked under a loose flake of the bark, or in a crevice, but is laid on the smooth bark, usually near the base of a small twig or a leaf scar. In the great majority of cases only a single egg is laid on a twig, but in a few cases two were observed close together and in one or two instances three were laid scatteringly along the stem. In hatching, the young larva bores into the bark through the bottom of the shell and packs the shell full of the borings. Most of the eggs are laid during the last of June and the first of July. All appear to hatch in from two to three weeks after they have been laid.

NUMBER OF GENERATIONS

The oak twig-girdler is a two-year species. Eggs laid in June of 1912, 1914 and 1916 produced beetles in 1914, 1916 and 1918. In many localities there is no brood of beetles during the alternate years. In some there are a few scattering individuals and in others there is a well-defined brood each year; that is, in June, beetles will be emerging from some twigs while year-old larvæ will be found in others; in January, eighteen-months old larvæ will be found in the large twigs and six-months old larvæ in the small ones. A most interesting occurrence was observed at Confidence, Tuolumne County, during August, 1919. All of the specimens found in the black oak were small larvæ from eggs laid in June, 1919, while all of those found in the canyon live oak were year-old larvæ from eggs laid in June, 1918.

NATURAL ENEMIES

Natural enemies undoubtedly play an important part in the life history of the twig-girdler. Nine species of Hymenopterous parasites were reared from the larval mines and pupal cells. One of these was a new species and new genus, and three others were new species. Messrs. S. A. Rohwer and R. A. Cushman identified the species and named the new ones.

Cryptohelcostizus rufigaster Cushman,¹ n. gen., n. sp., was reared several times from a single larva or cocoon found in the pupal cell of the girdler. Two *Cryptoideus fasciatus* Ashm. were reared from sim-

¹ Cushman, R. A., Proc., U. S. Nat. Mus., Vol. 55, pp. 534-35.

ilar pupal cells. *Doryctes maculipennis* Rohwer, n. sp., was reared from cocoons found in both the larval mines and the pupal cells. Another species of *Doryctes* was reared in numbers from cocoons found in the same places. In one locality near Palo Alto 50 per cent of the girdlers were parasitised by this species. Several cocoons occur packed in the same cell or mine. *Callihormius* sp. was reared from the larval mines and possibly the pupal cell.

Ptinobius agrili, Rohwer¹ n. sp., larvæ were found to emerge from pre-pupal girdler larvæ in the pupal cells and formed naked pupæ. Only a single one was found in each cell. *Metapelma spectabilis* Westwood was reared from the girdler-infested twigs. It may be a hyperparasite. *Tetrastichus anthracinus* Ashmead, a small black tetrastichid, was the commonest parasite reared. It occurred in numbers in the larval mines and pupal cells of the girdler. As many as seventeen larvæ were found in one girdler larva. Sometimes the girdler larva was killed before it made the pupal cell, and sometimes afterward. The *Tetrastichus* larvæ then emerged and formed naked pupæ in the mines or cells. *Dinotus agrili* Rohwer, n. sp., was reared several times from girdler-infested twigs sent in from Pasadena by Dr. A. G. Smith.

METHODS OF CONTROL

The best method of control developed at the present time is the pruning of the infested twigs. This should be done in the spring about April first before the beetles emerge. At this time both the twigs infested for one year and for two years are easily distinguished and those infested for the two years must be treated if the infesting insects are to be killed before they emerge. As many of the infesting girdlers are parasitised, it is better not to burn the infested twigs but to cage them in a box or barrel with the side or top made of number 16 mesh wire screen. The beetles cannot get through this and will soon die, while the parasites will escape and attack the twig-girdlers in the infested twigs overlooked in the pruning.

Poison sprays used against caterpillars in the spring kill some of the beetles as they feed on the foliage before mating. Contact sprays used against scales and other bark pests may kill some of the eggs, but it is doubtful if it will pay to use either of these if fighting only the girdler.

FIELD EXPERIMENTS FOR THE CONTROL OF THE APPLE MAGGOT

By GLENN W. HERRICK, Ithaca, N. Y.

In 1910 the writer urged Dr. J. F. Illingworth, then a graduate student at Cornell University, to undertake an investigation of the

¹ Rohwer, S. A., Proc. Ent. Soc. Wash., Vol. 21, pp. 5-8.

apple maggot with a view to its control by the sweetened poisoned baits which had been so successfully used for the control of the Mediterranean Fruit-fly in South Africa a few years previously. I pointed out that the insect had never been adequately controlled in this country and that if the poisoned baits proved effective here it would be a great boon to growers. The results of his work are found in Bulletin 324 of the Cornell University Experiment Station.

Illingworth's demonstration that the insect could be effectively controlled by the use of poisoned baits, sweetened or unsweetened, has now been substantiated by experimental evidence on a considerable scale, notably in Canada, and by the spraying practices of many practical fruit-growers. It is the purpose of this paper to add to these accumulating proofs of Illingworth's thesis the corroborative results obtained from some field orchard experiments made in New York during the season of 1919. In this connection I wish to acknowledge the invaluable aid of Mr. E. A. Rundlett, assistant Farm Bureau agent of Columbia County.

The apple maggot is abundant and destructive in the Hudson River Valley; and in Columbia County, according to a rather extensive and careful survey by Rundlett, it constitutes one of the two or three major apple pests. It has been particularly injurious to the Maiden Blush, Alexander, Greening, Baldwin, Duchess, and Northern Spy in the orchards of Mr. James Van Alstyne and Mr. A. T. Ogden near Kinderhook, N. Y. In the orchards of Mr. Van Alstyne, for the past four years, the Alexanders have been so seriously infested that few have been fit for shipping. All of them during the season of 1918 were seconds and a large part of them dropped and were worthless. The Maiden Blush apples have also dropped badly and in 1918, especially, were nearly worthless. The Baldwins and Greenings have been badly infested with the maggot and many of them reduced to seconds while a goodly percentage have been rendered worthless for market purposes.

In the orchard of Mr. Ogden last year (1918) seventy odd barrels of Northern Spies were produced on his trees of which only three-fourths of a barrel were of first quality. The others were so badly infested that they were either put in as seconds or not marketed at all. The crop was considered a failure. Nearly all of his other varieties were infested, especially the Baldwins and Duchess.

During the last days of June the writer, in company with Mr. Rundlett, visited the orchards named and arranged for the application of the poison sprays. Mr. Van Alstyne applied the first spray, 6 pounds of arsenate of lead to 100 gallons of water, on July 3. The second application was made on July 17 and 18, practically two weeks

after the first. The following table gives the weather conditions as recorded by Mr. Rundlett in Columbia County during this interval.

July 1. Warm and fair	July 10. Cool, rainy
2. Hot, fair	11. Cool, fair
3. Hot, fair	12. Warm, fair
4. Hot, fair	13. Fair
5. Hot, fair	14. Warm, fair
6. Warm, rain	15. Cool, cloudy, very humid
7. Warm, fair	16. Rain in morning, clear afternoon
8. Cool, fair	17. Warm, fair
9. Cool, fair	18. Warm, fair

The orchards on Mr. Ogden's place were sprayed first for the maggot on June 30 and the second time on July 17. Powdered arsenate of lead 3 pounds to 100 gallons of water was used in these orchards and since the places are near together the weather conditions were similar. It should be stated in this connection that the spraying was done rather thoroughly, care being taken to cover all of the foliage of each tree from the lowest to the highest branches. Moreover special effort was made to spray every apple tree on the place so as to leave no breeding grounds. I visited and examined the orchards in company with Mr. Rundlett on September 11. The Alexanders and Maiden Blush on the farm of Mr. Van Alstyne had been harvested. He said that 75 per cent of the Alexanders were of quality A and that the crop, as a whole, was fine. The Blush apples dropped but little, were remarkably free from infestation, and, as he expressed it, "were fine."

The Baldwins and Greenings were still on the trees and were in fine condition—as handsome a crop as I have seen this year. Later, Mr. Van Alstyne tells me, some infection of scab developed on the Greenings. Only occasionally could we find an infested apple on the trees and there were very few drops. It is worthy of note that two trees, one a Spy, close to the house, and another variety, the name of which I do not recall, that stood on an inaccessible bank behind the poultry house, were not sprayed. I believe that every apple on the Spy tree was infested with maggots and a very large percentage of those on the inaccessible tree. These two trees will be cut and burned before spring and thus the breeding grounds destroyed.

Perhaps the crop of Spies in the orchard of Mr. Ogden afforded the most striking example of the results of the spraying. The trees bore a fine crop, probably more than last year and we did not find an infested apple. So far as color, smoothness, and freedom from injury were concerned the apples, as the foreman said, would nearly all go in quality A. Size, however, would prevent such a realization. When the Spies were picked, however, a slight infestation was found which is

described in the following words by Mr. Ogden, "To my great delight I find almost no maggot. A little in the Spies but *almost none*—last year I could not get two barrels of good Spies out of 75."

Last year the Baldwins and Duchess in these orchards were badly infested. This year these varieties were practically free from infestation. In answer to my question, "Did the two applications of poison that you made control the apple maggot satisfactorily?" Mr. Ogden replied in the following words: "Absolutely. I doubt if we could do a better job. I have nearly 2,000 barrels this year and a very high per cent of A grade. I am satisfied by following same method we can control."

The results in these two carefully sprayed orchards were obtained in face of the fact that the maggot was more or less abundant in the whole of the western border of Columbia County and caused general loss to nearly all of the growers as Rundlett determined by his careful survey.

Situated near Mr. Van Alstyne's place is a large dairy farm having a small orchard on it of mixed varieties. It appears that all of the varieties in this orchard have been badly infested with the maggot for some years and we were anxious to have it sprayed as a matter of protection. We were able to induce the dairy foreman to give this orchard two sprayings at about the same time as the other orchards were sprayed although I do not have the exact dates. This orchard was sprayed with lime-sulfur and arsenate of lead each time. So far as we could judge in talking with the foreman the spraying had not been done with any great care or thoroughness and with little interest in the matter. The owner was ill and unable to look after any outside matters and the foreman is a dairyman. The results were not satisfactory to the entomologist although the foreman was very enthusiastic because the apples were so much freer of the maggot than they had been in previous years. As a matter of fact, there was considerable infestation in nearly all of the varieties we examined and a goodly percentage of drops. Either the addition of the lime-sulfur or the careless spraying or a combination of both factors prevented the success obtained in the other orchards where the prime object was to destroy the maggot.

Caesar and Spencer¹ have obtained experimental evidence which indicates that the cherry-maggot flies are not destroyed as effectively by a mixture of lime-sulfur and arsenate of lead as they are by arsenate of lead alone in water or by a combination of arsenate of lead, molasses, and water.

The results of these coöperative field experiments, it seems to me, show that rather more thorough spraying than I formerly deemed im-

¹ Caesar, L., and Spencer, G. J., Cherry fruit-flies, Dept. Agr., Ont. Can., Bul. 227, pp. 22 and 28, 1915.

portant is necessary to the most successful control of this insect. In addition to this I am convinced that all of the apple trees liable to infestation in an orchard should be sprayed in order to prevent any migration of the flies from untreated varieties. In any clean-up attempt all old derelict trees about the farm buildings should be thoroughly sprayed or else cut down and destroyed.

WILD HAWTHORNS AS HOSTS OF APPLE, PEAR AND QUINCE PESTS

By WALTER H. WELLHOUSE, *Ithaca, N. Y.*

The wild hawthorn trees have for many years been recognized by entomologists as the native hosts of a number of injurious native insects which now attack the apple, pear and quince, having adopted these hosts after they were introduced and cultivated in North America. Among the number may be mentioned the apple maggot, *Rhagoletis pomonella*, the dark apple red bug, *Heterocordylus malinus*, the quince curculio, *Conotrachelus crataegi*, the lesser apple worm, *Laspeyresia prunivora* and the woolly apple aphid, *Eriosoma lanigera*.

This migration to new hosts has been generally attributed to the close botanical relationship which exists between the hawthorns and the apple, pear and quince, all four being classed in the apple family. Another factor which tends to make these hosts interchangeable is their almost identical habitat. This allows insects which are restricted by differences in temperature, moisture, light or soil, as well as by botanical relationship, to accept apple in place of hawthorn. The native hawthorns grow wild in most of the apple and pear growing sections of the country. The planting of orchards in places where hawthorns were growing has already initiated a number of new fruit tree pests. With the continued extension of agriculture the uncultivated areas where hawthorns grow are still being reduced and their insect population must continue to seek substitute hosts.

The writer has a list of 374 species of insects which have been found to feed upon the hawthorns, and 210 of the species are found in the United States. Very few of these seem to be permanently injurious to the hawthorns and many of them do almost no injury, yet when they adopt as a host the apple, pear or quince which has been nursed and shielded from hardships so long that it has become tender and non-resistant, the injury may become much greater. For instance the puncture of the quince curculio in the side of a haw causes no great deformation of the fruit but its puncture in the side of a quince or pear will cause a marked depression and result in a knotty fruit.

Among the more important of the species which are now only *Cratægus* or hawthorn pests but which we may probably expect on our cultivated fruits later are the following:

The hawthorn blossom weevil, *Anthonomus nebulosus* Lec. Its life history and habits are identical with those of the apple blossom weevil of Europe which, according to Theobald, sometimes destroys 40 per cent of the apple crop in England. As yet our species attacks only *Cratægus* but its habit of attacking the fruit buds would make it a very dangerous pest if it should attack the apple.

The hawthorn fruit miner, *Blastodacna curvilineella* Chamb. The larvæ of this little Cosmopterygid are among the most common causes of "wormy" haws in Central New York and they probably are distributed at least over the eastern states. The larvæ have the habit of leaving the fruit in early autumn and burrowing into a dead twig or weed stem to spend the winter. They have undoubtedly been long overlooked because they are very active and work their way through the breeding cages to escape even through several layers of fine meshed cheese cloth.

A new leaf bug, *Lygus univittatus* Knight, resembling the false tarnished plant bug in appearance, has been found by the writer puncturing the fruits of *Cratægus* at Ithaca and Knight believes this will eventually become an apple pest. Its punctures do not deform the haws to any extent but may affect the apple differently.

A number of leaf-hoppers, the most numerous of which are *Empoa querci*, *Lamenia vulgaris*, *Erythroneura obliqua*, and *Idiocerus provancheri*, cause considerable damage to the *Cratægus* foliage.

The four-spotted hawthorn aphid, *Macrosiphum cratægi* Monell, remains all summer on hawthorn and has caused much damage to the trees even during warm dry weather. It is easily distinguished from our common hawthorn and apple aphids by the four conspicuous dark green spots arranged in a rectangle on the backs of the apterous females.

Argyresthia oreasella Clem. A little white and gold bud moth which in the larval stage bores into the terminal buds causing them to wilt and die in May. The blackened terminals are occasionally very numerous on hawthorns about Ithaca.

Over 100 species of insects which feed on apple also feed on hawthorns. Among them are the following common apple pests:

False tarnished plant bug, *Lygus communis*

Apple aphids (*Aphis avenæ*, *A. pomi*, *A. sorbi*, *Eriosoma lanigera*)

Scale insects (*Aspidiotus perniciosus*, *Chionaspis furfura*, *Lepidosaphes almi*, *Lecanium corni*, etc.)

Flea beetles (*Haltica foliacea* Lec., *Crepidodera helzines* Linn., etc.)

Apple curculio, *Anthonomus quadrigibbus*
 Plum curculio, *Conotrachelus nenuphar*
 Apple weevil, *Pseudanthrenomus crataegi*
 Hickory tussock moth, *Halsidota caryæ*
 White marked tussock moth, *Hemerocampa leucostigma*
 Antique tussock moth, *Notolophus antiqua*
 Yellow-necked apple caterpillar, *Dalana ministra*
 Red-humped apple caterpillar, *Schizura concinna*
 Tent-caterpillars, *Malacosoma americana*, *M. disstria*
 Fall webworm, *Hyphantria cunea*
 Leopard moth, *Zeuzera pyrina*
 Canker-worms, *Alsophila pometaria*, *Paleacrita vernata*
 Bud moths, *Tmetocera ocellana*, *Recurvaria nanella*
 Leaf rollers, *Archips argyrospila*, *A. rosaceana*, *Ancyliis nubeculana*, *Eulia quadrifasciana*
 Lesser apple worm, *Laspeyresia prunivora*
 Case bearers, *Coleophora fletcherella*, *C. malivorella*
 Leaf miners, *Tischeria malifoliella*, *Ornix geminatella*
 Leaf crumpler, *Mineola indigenella*
 Apple maggot, *Rhagoletis pomonella*

The popular belief that the round-headed apple-tree borer, *Saperda candida*, and the codling moth, *Cydia pomonella*, are common feeders on *Crataegus* has not been borne out by the writer's observations. In a number of natural thickets where hawthorns and seedling apple grow together the round-headed borers have been watched for two years. The adults were quite commonly found resting on the foliage of both hawthorn and apple in June and July but the larvæ could be found only in the apple. The apple was so heavily infested that very few trunks remained standing and many young sprouts from the roots had grown up in their places. The larvæ were found girdling these sprouts and were also infesting a well kept orchard across the railroad track. The hawthorns showed no sign of having been touched by the borers. At least two of our common species of hawthorns, *Crataegus punctata* and *C. pruinosa* were present in these thickets.

The codling moth has not been found among the insects reared from the haws during the past two seasons and only one record has been found of its ever being reared from hawthorn. That is in the notes of the late Professor Slingerland. He states that in September 1890 "I gathered a lot of haws and placed them in cages to breed the codling moth. Examined several (25 perhaps) of the haws and never failed to find at least one larva in each. May 13 one adult emerged. Several other smaller moths were found in the cages also. May 19 one adult emerged and is pinned." The smaller moths were probably the lesser apple worm, *Laspeyresia prunivora*, since this species has been reared in abundance from the haws. The larvæ of *L. prunivora* have undoubtedly been mistaken for those of the codling moth in

many cases and since their resemblance is very close it is not surprising that the codling moth was believed to breed quite commonly in haws.

In view of the fact that the wild hawthorns are hosts of many of our present apple, pear and quince pests and also of many potential insect pests, not to mention the cankers, blights and rusts which they may harbor, should we not remove them from the vicinity of our orchards or at least give them insecticidal treatment? The cumulative benefit which would be gained from spraying an orchard several years in succession may be lost if the surrounding country continually furnishes a new supply of pests.

SOME STUDIES ON THE EFFECT OF ARSENICAL AND OTHER INSECTICIDES ON THE LARVÆ OF THE ORIENTAL PEACH MOTH

By ALVAH PETERSON, *Assistant Entomologist, New Jersey Agricultural
Experiment Station*

INTRODUCTION

The oriental peach moth, *Laspeyresia molesta* Busck is found in several localities in New Jersey. It is particularly abundant in orchards about Red Bank and New Brunswick. The author has given this pest considerable attention for two seasons, 1918 and 1919.

During these seasons it has been noted that there have been at least three full broods and a partial fourth. The first larval injury to the twigs in 1919 was seen the first week in June at Mr. J. C. Hendrickson's three year old peach orchard (Hale variety) near Middletown, N. J., at that time no tree possessed over ten injured twigs. In 1918 this orchard was severely infested. Some of the trees had over 90 per cent of the twigs injured during the month of July. During 1919 the infestation in this orchard was approximately 50 per cent less than in 1918. The last freshly injured twig observed in 1919 was found on August 30 in the orchard at the college farm.

Twig injury to peach trees is most severe during the first three years after the trees are set out in the orchard. It has been repeatedly observed that in old orchards (five years or more) twig injury is not serious. Several old orchards have been examined which are adjacent to heavily infested young orchards and little or no twig injury could be found. It is apparent that the larvæ prefer young, tender, vigorously growing shoots.

The first fruit injury in 1919 was seen the last week in June while the last fruit infestation was observed on September 10 at New Brunswick. So far as known, no fresh larval injury of any description has been seen

after this date in New Jersey. Fruit injury to peaches has seldom exceeded 10 per cent of the crop in any orchard in this state. In most orchards it was much less than 10 per cent. This pest has also been found attacking the fruit of apple and quince trees in New Jersey. Entomologists in other states have recorded injury to cherry, plum and apricot trees and also to ornamental fruit stock.

The larva, when it hatches from the egg is very small, somewhere between 1-2 mm. in length. When it is full grown it measures 12-13 mm. in length. The larva usually enters a growing peach twig at its distal end; however, it may make its way into the shoot near the base of a leaf petiole or the point of entrance may be the petiole itself. Before it enters it usually spins a loose silken cocoon about its body. The silken threads close the open spaces between the leaves at the point where the larva enters. Larvæ that are half grown or larger seem to be more inclined toward spinning a loose cocoon before entering than very small larvæ. Usually before the silken cocoon is completed the larva proceeds to bite out pieces of green tissue from the stem or small leaves and places these particles on the thin web about its body. The green particles soon dry and turn brown, thus making a collection of brown frass at the point of entrance.

So far as known, the larva does not consume any of the outer green tissue of the twig at the point where it enters. It, apparently, waits until it is within the stem before it partakes of food. The above fact seems to be true of all larvæ, particularly those that are half grown or larger. Other investigators have also recorded the above observations in respect to the feeding habit of the larva. Since the larva fails to consume the outer green tissue as it enters a shoot this probably accounts for our failure to obtain a satisfactory control in orchard experiments with arsenical sprays in 1918.

One larva may enter several growing shoots, three or more, before it obtains sufficient food to complete its larval development. This fact, in part, accounts for the large number of injured twigs one may observe on a heavily infested tree and yet find comparatively few larvæ.

Larvæ also enter the fruit of peach trees. Many of them go into the fruit near the stem end, but they also enter the sides of the peaches. The larvæ usually deposit a mass of green tissue at the point of entrance on the fruit. Here again the larvæ, apparently, do not consume their first mouthfuls of peach tissue.

EXPERIMENTS

During 1918 a number of severely infested trees were carefully sprayed with arsenical mixtures of varying strengths. In no case were we able to get over a 50 per cent reduction in the number of

infested twigs and on some trees the infestation was not appreciably reduced. This season instead of carrying on extensive orchard experiments most of the tests were conducted at the laboratory and on small individual trees. Under these conditions we could carefully watch the behavior of the larvæ.

The following tables show the results of placing individual (usually no more than one on a twig or fruit) larvæ on treated, freshly cut, peach twigs and treated, freshly picked green fruit. When liquid sprays were used, the material was applied with a small hand atomizer in such a way as to thoroughly coat the twig or fruit. Casein-lime composed of 50 per cent casein (lactic) and 50 per cent hydrated lime was used as a spreader for some of the liquid sprays. The larvæ were placed on the liquid treated twigs and fruit as soon as they were dry. The dusts were placed in a small hand dusting bag which was made of two thicknesses of fine mesh cheese-cloth and then shaken onto the twigs or fruit.

In Tables I and II the larvæ used in the experiments varied in length from 5-9 mm. while in Table III the exact size of each larva was known. In Table III the larvæ have been grouped into three sizes, 2-4, 5-6, and 7-9 mm. Larvæ larger than 9 mm. were not used because the majority of them (upon removal from a twig) show a strong tendency to seek a place to build a cocoon and pupate rather than reënter a new shoot or fruit. Whenever material was needed for experiments, newly infested twigs were collected from nearby orchards and the larvæ were removed. They were immediately placed on newly treated, freshly cut twigs or fruit. The cut ends of the twigs were placed in water to keep them fresh while the individual peaches were each placed under a separate glass dish. Observations on most every test were made 12, 24 and 48 hours after the start of each experiment. The observations recorded in the tables were taken 48 hours after the experiment was started. This gave sufficient time for the poison to act on the larvæ provided they consumed the same. In order to be sure of this point observations were always made at the end of three to five days with each substance tested and in no case was there any change in the results compared with the 48 hour record. In most instances the larvæ had entered or started to enter the twigs or fruit 12 hours after they were placed on the same. If they did not enter in this period they usually refused to do so. Many of the larvæ recorded as lost or in the column showing no injury or no larva seen, were present, alive and active at the 24 hour period, but for some reason disappeared by the 48 hour period. They may have become dislodged while wandering over the smooth surface of the twigs or it is probable that some of them were poisoned.

The results of the liquid spraying experiments with the twigs (Table I) show that one or more larvæ were able to penetrate any of the coatings put on the new peach shoots and safely reach the center of the treated twig. None of the arsenical sprays employed stopped the larvæ from entering. In a few instances some of the younger larvæ seemed to be repelled by the poisoned material.

The results of the dusting experiments (Table II) show a very small percentage of kill. With the exception of Paris green, two or more larvæ in each set of tests entered the thoroughly dusted twigs. Paris green and magnesium arsenate showed the greatest percentage of kill, but these substances by themselves will injure peach foliage. Helio-bore, pyrethrum, tobacco lime and lime-sulfur dusts were also tried. None of these were effective except pyrethrum. This substance seemed to have a repellent effect. The larvæ were not killed by the pyrethrum, but most of them refused to enter the twigs coated with this dust.

Table III shows the response of larvæ of known size to lead arsenate mixtures (lime and sulfur) when used in liquid and dust forms. The poison was thoroughly applied to immature peaches. A very small percentage of the 2-4 mm. and 5-6 mm. larvæ, but none of the 7-9 mm. larvæ, were killed by the lead arsenate when it was applied in liquid form at the rate of 2 to 4 pounds to 50 gallons of water with the addition of casein-lime, 2 pounds to 50 gallons, acting as a spreader.

All larvæ smaller than 4 mm. were killed when placed on fruit coated with a fine dust of lead arsenate, 1 part and hydrated lime, 5 parts or lead arsenate, 1 part and finely ground sulfur, 1 part. Of the two mixtures the lead arsenate and sulfur mixture was more effective with the larger larvæ for it killed over 80 per cent of the 5-6 mm. larvæ and 30 per cent of the 7-9 mm. larvæ while the lead arsenate and lime dust only killed 60 per cent of the 5-6 mm. larvæ and 2 per cent of the 7-9 mm. larvæ. Finely divided hydrated lime by itself killed 40 per cent of the 2-4 mm. larvæ and over 35 per cent of the 5-6 mm. larvæ, but none of the 7-9 mm. larvæ. This substance does not act as a stomach poison, but the lime seems to make it difficult for the small larvæ to crawl over a coated surface. The fine dust-like particles of lime catch on the ventral aspect of the body and also cling to the fine setæ scattered over the various segments. This probably causes the thin skin of the larva to become very dry. Many of the larvæ on the dusted fruit seemed to gradually decrease in size and shrivel before they died.

The coating of dust on the fruit in the above experiments was probably somewhat heavier than what might be found on the average fruit when dusted under orchard conditions. The results of the above dust-

TABLE I.—THE EFFECT OF ARSENICAL AND OTHER LIQUID SPRAYS ON LARVÆ OF VARIOUS SIZES (5-9 MM.) WHEN THE LARVÆ ARE PLACED ON TENDER GROWING PEACH TREE TWIGS WHICH ARE THOROUGHLY COATED WITH THE SPRAY MIXTURE

Experiment number	Liquid sprays	Larvæ alive inside of twig	Larval injury but no larvæ seen	Larvæ dead	Larvæ alive outside of twig	No larvæ or injury seen	Total larvæ in trials
1	Lead arsenate, 2 lbs.-50 gals.	6	1	0	2	4	13
2	Lead arsenate, 2 lbs.-50 gals., plus casein-lime, 2 lbs.-50 gals.	8	0	0	1	3	12
3	Lead arsenate, 4 lbs.-50 gals.	6	0	0	0	0	6
4	Lead arsenate, 4 lbs.-50 gals., plus casein-lime, 2 lbs.-50 gals.	4	0	0	1	2	7
5	Calcium arsenate, 2 lbs.-50 gals.	12	1	0	0	0	13
6	Calcium arsenate, 2 lbs.-50 gals., plus casein-lime, 2 lbs.-50 gals.	3	1	0	0	1	5
7	Magnesium arsenate, 2 lbs.-50 gals.	8	0	0	1	3	12
8	Magnesium arsenate, 2 lbs.-50 gals., plus casein-lime, 2 lbs.-50 gals.	5	1	0	0	0	6
9	Zinc arsenite, 2 lbs.-50 gals.	3	1	0	1	0	5
10	Zinc arsenite, 2 lbs.-50 gals., plus casein-lime, 2 lbs.-50 gals.	5	0	0	0	3	8
11	Paris green, 2 lbs.-50 gals.	6	0	0	0	2	8
12	Paris green, 2 lbs.-50 gals., plus casein-lime, 2 lbs.-50 gals.	3	2	0	0	1	6
13	Hellebore, 1 gm.-100 cc., plus f. o. soap, 1 gm.-100 cc.	3	3	0	0	1	7
14	Nicotine, 1 cc.-500 cc., plus f. o. soap, 1 gm.-200 cc.	2	0	0	0	5	7
15	Nicotine resinate, 1 cc.-500 cc.	8	0	0	0	6	14
16	Crude carbolic acid, 1 cc.-99 cc., plus f. o. soap, 1 gm.-200 cc.	1	0	0	2	4	7
17	Lime-sulfur, 1 cc.-40 cc.	3	0	0	0	0	3
18	"Sealecide," 1-40	5	0	0	0	0	5
19	"Sulfolim," 1-50	3	0	0	1	4	8
20	Cheek	9	0	0	0	1	10

ing experiments with fruit show that the small larvæ may be killed by a combination of lead arsenate and lime or lead arsenate and sulfur, but many of the larger larvæ will not be killed.

A series of experiments were conducted with fruit in place of tender peach twigs. The insecticides used were similar to those shown in Tables I and II. The results obtained (not shown in table form) were in many ways similar to those shown in Tables I to III. The various arsenicals applied as dusts to the fruit were superior to liquid sprays in killing the larvæ, yet in no case was there a complete control. A few of the larvæ were killed when the arsenicals were used in liquid

TABLE II.—THE EFFECT OF ARSENICAL AND OTHER DUSTS ON LARVÆ OF VARIOUS SIZES (5-9 mm.) WHEN THE LARVÆ ARE PLACED ON TENDER GROWING PEACH TREE TWIGS WHICH ARE THOROUGHLY DUSTED WITH THE MIXTURES

Experiment number	Dusts	Larvæ alive inside of twig	Larval injury but no larvæ seen	Larvæ dead	Larvæ alive outside of twig	No larvæ or injury seen	Total larvæ in fruit
21	Lead arsenate	6	0	0	1	2	9
22	Lead arsenate, 1 pt.-lime 5 pts.	11	3	0	0	0	14
23	Lead arsenate, 1 pt.-sulfur 1 pt.	10	2	1	1	3	17
24	Calcium arsenate	6	0	2	0	2	10
25	Calcium arsenate, 1 pt.-lime 5 pts.	10	0	0	0	5	15
26	Magnesium arsenate	3	0	1	4	3	11
27	Magnesium arsenate, 1 pt.-lime 5 pts.	4	1	1	2	10	18
28	Zinc arsenite, 1 pt.-lime 5 pts.	8	2	0	1	4	15
29	Paris green	0	1	3	1	1	6
30	Paris green, 1 pt.-lime 5 pts.	2	2	1	0	3	8
31	Hellebore	6	2	0	1	5	14
32	Hellebore, 1 pt.-lime 5 pts.	5	0	0	1	0	6
33	Pyrethrum	4	0	0	5	10	19
34	Pyrethrum, 1 pt.-lime 5 pts.	4	0	0	1	4	9
35	Tobacco	10	0	0	0	4	14
36	Tobacco, 1 pt.-lime 5 pts.	2	1	0	0	8	11
37	Lime (hydrated)	8	0	0	0	0	6
38	Lime-sulfur	4	1	0	0	1	6
39	Check	12	0	0	1	1	14

form at the rate of 4 pounds to 50 gallons of water, but when the arsenicals were used at the rate of 2 pounds to 50 gallons of water, except Paris green, none of the larvæ were killed. When the arsenicals were applied as dusts the calcium and magnesium arsenates, alone or in combination with hydrated lime, killed approximately the same percentage of larvæ as the lead arsenate (alone or in combination with lime). Dusts of hellebore, pyrethrum and tobacco did not keep the larvæ out of thoroughly coated fruit. Pyrethrum seemed to have a slight repellent effect.

Comparing the various series of experiments where twigs were used with those where peaches were used, the best killing results were obtained in the fruit series. This may be due to the fact that it is exceedingly difficult to get a thorough coating of poison (liquid or dust) on and into all parts of a growing peach twig. The surface of the leaves and stem on a peach twig is smooth and this makes it difficult for the

TABLE III.—THE EFFECT OF LEAD ARSENATE (LIQUID AND DUST MIXTURES) ON LARVÆ OF KNOWN SIZE. THE SPRAY AND DUST MIXTURES THOROUGHLY COATING THE ENTIRE SURFACE OF IMMATURE PEACHES

Experiment number	Liquid sprays and dusts	2-4 mm. larvæ		5-6 mm. larvæ		7-9 mm. larvæ		Total larvæ	
		Entered	Dead	Entered	Dead	Entered	Dead	Entered	Dead
40	Lead arsenate, 2 lbs.-50 gals., plus casein-lime, 2 lbs.-50 gals.	8	5	48	1	29	0	85	6
41	Lead arsenate, 4 lbs.-50 gals. plus casein-lime, 2 lbs.-50 gals.	8	3	39	3	27	0	74	6
42	Lead arsenate, 1 pt.-lime 5 pts. (dust)	0	8	17	28	44	1	61	37
43	Lead arsenate, 1 pt.-sulfur 1 pt. (dust)	0	15	8	38	42	18	50	71
44	Hydrated lime (dust)	6	4	22	14	39	0	67	18
45	Check	13	0	29	0	32	0	74	0

material to stick. Dusts adhere better than liquid sprays due to the fact that a growing peach shoot has a somewhat sticky surface. The surface of a peach is pubescent, consequently liquid sprays and dusts readily cling to its surface. Again it is probable that a larva entering a thoroughly dusted fruit is more apt to consume some of the poison than a larva entering a twig.

In addition to the above experiments with peach twigs and fruit a number of immature apples were dusted and sprayed with various lead arsenate mixtures (as given in Table III). In no case did the poison prevent the larvæ from entering the fruit. The larvæ used in these experiments were at least half grown and larger.

Dr. P. Garman suggested the spraying of infested twigs with arsenical poisons with the hope of killing the worm as it ate its way out of the twig. The larva usually eats its way out of the twig near the terminal end of its interior channel. This may be several inches from the point of entrance. Fifty twigs were collected which seemed to possess living larvæ. Twenty-five of these were thoroughly sprayed with lead arsenate at the rate of 4 pounds to 50 gallons of water with the addition of casein-lime, 2 pounds to 50 gallons of spray and the other twenty-five twigs served as a check. Ten days after the experiments were started the cloth cages in which the experiments were enclosed were examined. The check showed sixteen larvæ alive on the walls of the cage or pupating in cocoons and one dead, while the sprayed lot showed fourteen larvæ alive on the walls of the cage or pupating and two dead. This experiment was repeated and similar results were

obtained. These two tests show that a coating of lead arsenate on an infested twig has little or no effect on the larva when it eats its way out.

The author hoped to make a careful study of the response of newly hatched larvæ to the various sprays which have been used in the above experiments. Unfortunately he was unable to secure a sufficient quantity of fertilized eggs to make this investigation. Caged adults and field collections did not give a sufficient supply. Newly hatched larvæ will probably respond to the above insecticides in the same way as the 2-4 mm. larvæ. It is also probable that they are more susceptible. If such is the case thorough dusting of fruit and tender growing twigs with some arsenical insecticide should kill all of the newly hatched larvæ as they enter a thoroughly dusted fruit and possibly all of the newly hatched larvæ as they enter a thoroughly dusted twig.

DIPPING TOBACCO PLANTS AT TRANSPLANTING TIME FOR THE CONTROL OF THE TOBACCO FLEA BEETLE (*EPITRIX PARVULA* FABR.)

By Z. P. METCALF, *North Carolina State College and Experiment Station*

One of the critical times in the life of a tobacco plant is naturally just after it has been transplanted and added to this natural handicap is an artificial handicap caused by the presence of swarms of tobacco flea beetles which come from the tobacco beds and other feeding places and do great damage to the plants at this season of the year. This injury results in a weakening of the plant and may cause its death. In the latter case the loss is total unless a new plant is used to replace the dead plant. The loss due to these attacks is normally very great every season and may be divided into two items: a direct loss due to the additional labor involved in replanting and an indirect loss due to the slow growth of the injured and replanted plants, which makes them mature later in the fall. Such plants as these are always badly damaged by flea beetles just before harvest time.

With these points in mind we have been working for the past three years to devise a method for tiding the tobacco plants over this critical period. Reduced to its simplest terms our directions at present are to prepare a solution of arsenate of lead into which the plants are dipped. This mixture should be carefully prepared and kept thoroughly agitated by stirring frequently with a paddle. Then as the plants are pulled from the bed they should be laid out straight in small bundles. Each bundle should be picked up separately and the leaves only dipped into the arsenate of lead solution. The plants should be separated as much as possible while they are in the solution, so that every leaf will receive a coating of the poison. As the plants are withdrawn they should

be shaken slightly to remove the excess poison. Care must be taken not to shake them too violently or too much of the poison will be removed. After a few bundles are dipped look at the first bundles and notice whether the leaves are completely and uniformly covered with a dry white powder. If large drops of water have collected here and there on the leaf it means that the plants should be shaken a little bit more as they are removed from the poison. Tobacco plants can be set practically as rapidly in this way as by the old method, for the additional labor involved is very slight indeed.

The other factor involved was to determine just what strength of arsenate of lead solution to use. Apparently the tobacco plant, when properly hardened off before transplanting, will stand almost any amount of arsenate of lead. Plants have been dipped in solutions of arsenate of lead as strong as 20 pounds of dry powder to 50 gallon of water without any injurious effects appreciable. However, solutions as strong as this are not necessary and this past year we carried on a series of experiments to determine whether 1 pound or 2 pounds of powdered arsenate of lead to 10 gallons of water would give the better results. Briefly the results of an inspection made two weeks after the plants had been transplanted may be summarized as follows:

TREATED WITH ARSENATE OF LEAD ONE POUND TO TEN GALLONS OF WATER

	Per Cent
Plants not injured	51.3
Plants slightly injured	35.4
Plants badly injured	5.6
Plants replanted	2.6
Plants badly sun scalded	5.1

TREATED WITH ARSENATE OF LEAD TWO POUNDS TO TEN GALLONS OF WATER

	Per Cent
Plants not injured	63.0
Plants slightly injured	22.6
Plants badly injured	1.0
Plants replanted	3.6
Plants badly sun scalded	9.8

CHECK

Plants not injured	0.0
Plants slightly injured	7.1
Plants badly injured	91.1
Plants replanted	1.1
Plants sun scalded . . . . .	.7

Analyzing the above results we find a total effectiveness for the one pound of lead of 78 per cent, counting both the uninjured and slightly injured, as effectively treated and assuming on the basis of the check that only 90 per cent of the plants would be badly injured in this time

and a total effectiveness of 77 per cent for the two pounds of arsenate of lead. On the other hand nearly 6 per cent of the plants treated with one pound of lead were badly damaged as against 1 per cent for the plants treated with two pounds. The number of replants made up to this inspection is practically identical. Later inspections, however, show a decided advantage for the treated plots, only 2 per cent being replanted whereas the check plot showed 17 per cent replants. The term sun scalded is used to express an unknown factor which caused a burning on the tips of the leaves and which might be attributed to the poison used, especially in light of the fact that this condition was nearly twice as bad in the plants treated with two pounds as it was in the plants treated with one pound, but for the following facts, some of the plants in the check plot were also badly scalded and an adjacent field set on the following day which received no treatment was sun scalded worse than the treated plots.

In view of these experiments our recommendation to the farmers is that the plants should be dipped in arsenate of lead, 1 pound powder or 2 pounds paste, to 10 gallons of water.

THE LIFE HISTORY OF THE POTATO LEAFHOPPER (EMPOASCA MALI LE BARON)

By F. A. FENTON and ALBERT HARTZELL, *Iowa State College, Ames, Iowa*

The potato fields of Iowa and the surrounding states have suffered severely from burning for several years until this condition has become a seriously limiting factor in the production of this crop. Dr. Ball¹ has previously demonstrated that the potato leafhopper was responsible for this condition and has aptly termed the disease "hopperburn." This discovery made the control of the leafhopper the most important problem in connection with potato production.

In order to control this insect it was first necessary to know its life history on potato, of which little was known, owing principally to the fact that these hoppers were so minute, active, and difficult to keep alive under artificial conditions. The problem of its life cycle was primarily one of the proper technique. Much time was therefore spent in perfecting methods and devices for keeping these insects under observation. The methods employed at the outset were only partly successful but later were improved with satisfactory results on all important phases of the study.

CLIMATIC FACTORS

The season of 1919 was abnormal in the excess of early precipitation followed by exceedingly high temperatures. There were two long

¹ Science, N. S., Vol. 48, Aug. 1918, p. 194. Jour. of Econ. Ent., Vol. 12, No. 2, 1919, pp. 149-154.

periods of drought, the first extending from early June to early August, and the second from the middle of August to the middle of September. A maximum high temperature average was reached by the middle of June, and lasted until early September, the hottest period coming in late July.

EXPERIMENTAL METHODS

Data was obtained largely from cage experiments and checked up by field observations. The cages were kept in a greenhouse which was shaded and well-ventilated and in the fields under as normal conditions as possible. Records on the first or summer generation were based on observations made on a plot of early Ohio potatoes at Ames,

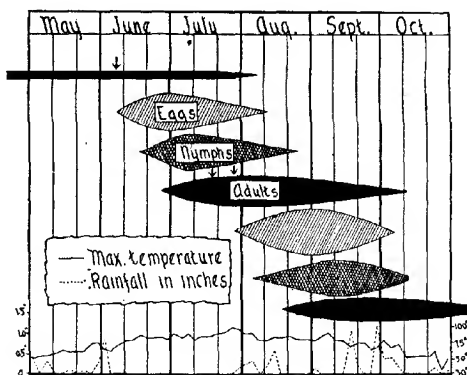


Fig. 13. Life history of *Empoasca mali* in potato

Iowa, while the experiments on the second generation were conducted on late varieties planted at Ames, and also on late potato fields in Mitchell County, Iowa.

SUMMARY OF SEASONAL HISTORY

The potato leafhopper overwintered in the adult stage. These adults became active as early as April and were found on various weeds until June. They then deserted the weeds and migrated to early-planted potatoes as shown by the arrow on the life history chart. The females immediately began laying eggs on these vines, and continued to do so until late July, when most of them died. The first nymphs or young appeared on the vines by the middle of June, and became especially abundant late in this month and early in July, at which time they caused the potato vines to burn badly. By August,

these first brood nymphs had largely disappeared, having matured into the summer generation of adult hoppers. These began appearing on the potato vines early in July and by the middle of this month were very numerous. They then migrated to the late potato fields which up to this time had been practically free from infestation. On them the females laid eggs which hatched into the second brood nymphs in late August and early September. These nymphs became especially abundant during the latter month producing the hopperburn on the late potato vines. At the time of frost all immature stages and summer brood adults were killed. Second generation adults matured from late August on, but did not lay eggs and produce a third brood. They remained on the vines until frost, when they flew to various weeds and other hardy plants that had not been touched by the cold. Here they stayed until these vines in turn were frosted, when they entered hibernation.

SPRING FLIGHT

Adults were found in small numbers feeding on grasses during April and early May, but they did not appear in any considerable numbers until late in this month, when they were very numerous on weeds and grasses. They were especially abundant on the common yellow dock, *Rumex crispus* L., which they preferred to several other kinds of weeds and young apple stock growing near by. Potted potato plants were placed among these weeds but were not touched by the hoppers. Similar conditions were observed everywhere. In no cases were they found on either apple, beans, or potatoes, in spite of the fact that they were present in numbers on other plants at this time.

On the morning of June 6 they suddenly left the weeds and migrated in large numbers to the potato plants. This phenomenon was observed generally and by several different persons. At this time there had been a drop of several degrees in temperature and a light shower. Just previous to this, there had been a period of rather high temperature followed by a rain, during which the mercury had dropped. This sudden and complete migration, coming at such a definite time, was evidently closely correlated with such climatic factors as temperature and humidity, as well as with sexual maturity, for females dissected at this time contained the first ripe eggs. At the time of this flight late planted potatoes were either not up, or just appearing above the soil, and thus were not infested by the hoppers. They remained free from these insects until the late July flight of the summer generation hoppers, thus proving that there was but one flight of the overwintered adults, and that once they had settled on the early potato fields there was no further dispersal.

SUMMER FLIGHT

A general summer migration from early to late potatoes was observed in July. This took place over a considerable period of time, depending partly on the condition of the potato vines. In fields that had burned badly there was an early flight to either late potatoes or to fields in which many vines were still green. Otherwise this summer flight did not take place until late in July. That this was primarily not a forced migration because of lack of food plants was shown by the fact that it occurred in fields where there were still many green plants. Several fields were noted where, because of an especially severe infestation, the flight had been early, thus giving the vines a chance to send up vigorous sprouts. These were infested by adults from other fields that had burned late. However, in due time, no matter whether the vines were still green, the migration or mating flight was begun. It was evidenced at first by the swarming of the males at electric lights in the evening. In our experimental plots a row of Green Mountain potatoes, which had been practically free from infestation because the plants were not up at the time of the spring flight, received the first exodus from the surrounding early planted fields. This visitation was short, lasting only three or four days, but it was long enough to cause the vines to burn quite badly. Almost in a night, however, the hoppers disappeared from these vines and began their summer dispersal flight to late potato fields, leaving only a few scattered immature individuals. A few days later adult hoppers again appeared on these plants coming in from the surrounding fields.

This summer migration differed from the earlier spring flight principally in that it occurred over a longer period of time. This apparent difference may be explained by the fact that the earlier summer flights were due to lack of food and that the real migration and sexual flight took place as suddenly as it did in the spring. The highest temperatures of the season were recorded at this date but there was no rainfall.

HOW LONG DO THE OVERWINTERED ADULTS LIVE?

Shortly after their appearance on the potato vines, eleven pairs of adult hoppers were placed in small cages for longevity records, while about fifty were collected and placed in a large wire cage as a check. The first female of the eleven pairs was observed dead July 9, most of them dying between July 21 and 23, while one lived until August 4. Similar records were obtained from the large cage, and July 26 all the hoppers in this were dead.

Further evidence that these females did not live much longer than late July was obtained by caging adults collected in the field at this

time on potato plants for oviposition records. But few nymphs hatched in these cages, showing that the overwintered females used had largely stopped laying eggs. This was also true in all the early potato fields observed, since most of the nymphs noticed on the plants were in the late instars and very few were hatching.

When the hoppers first migrated to the potato fields hundreds were examined for the proportion of sexes, which was found to be about even. By the middle of June there was a decided preponderance of females although there were still many males. June 30 it was very difficult to find a male in the field, and after a long search five were collected and placed in cages with females. Four of them died within a week, and one lived until July 8.

HOW LONG DO THE FIRST BROOD ADULTS LIVE?

Females of the first or summer generation were appearing in greatest abundance about July 10. Those maturing in cages at that period, owing to artificial conditions, began to die within a short time, while the longest records were twenty-four to twenty-five days. A month later most of this brood had become adult. Some of these later matured ones were caged and kept as long as they lived. They began to die as in the case of the earlier ones, but the more vigorous lived from twenty-five to thirty days and one survived until October 17, a period of sixty-one days.

Males lived on an average of ten days under cage conditions with a record of twenty-six days. In the majority of instances it was observed that the males died long before the females and shortly after copulation. Thus it would seem that the twenty-six day record was unusual.

HOW LONG DO THE SECOND BROOD ADULTS LIVE?

Two series of cages were started in August and September to determine the length of life of the second generation adults. In the first series, one hundred pairs were kept in small cages and examined daily. Of this series twenty-two females and five males were alive October 17, or approximately 25 per cent. The higher percentage of mortality in the males was due to their greater activity. The second series consisted of five large cages each containing one hundred adults that had been collected in the field. The majority were alive November 8, when last examined, showing that under more natural conditions second brood adults lived throughout the fall and were alive at the start of winter.

Thus the second generation adults appeared in the fields in August and September and lived throughout the winter, becoming active again in the spring, many living until early August, a period of from

eleven to twelve months. On the other hand the first or summer generation in small cages lived from fifteen to sixty days, while in large field cages they averaged forty-five to sixty days. Under field conditions, probably two months was the average length of life as indicated by the fact that there was a definite maximum period of hatching of young which extended for approximately forty-five days.

OVIPOSITION

Owing to the minute size of the egg and its concealment in the plant tissues it was impossible to make egg counts. In order to get daily records, females were placed with potato leaves for twenty-four hours and then these leaves were removed, labeled, and placed with their stems in water. From the number of nymphs that issued an estimate of the number of fertile eggs was obtained. Difficulty was experienced in keeping the potato leaves fresh long enough for the eggs to hatch, and so the records are incomplete in this respect. Two series of overwintered females were caged to obtain egg records. In June the females were caged before they had begun oviposition, while those caged July 1 had already been laying since June 6.

TABLE I. AVERAGE NUMBER OF FERTILE EGGS LAID PER DAY BY FEMALES

Number eggs laid per day.....	1	2	3	4	5
Number of records.....	72	21	5	4	2

The above table summarizes the results. In the majority of cases under cage conditions but one egg a day was laid, although frequently this was increased to two. Occasionally three, four, or even five were deposited and on some days none. Females dissected showed a maximum of four eggs matured at one time.

In general, oviposition of the overwintered females did not begin until after the spring flight. A few nymphs were found hatching on sweet clover in June for a short time, showing that some females had oviposited before migrating to potato. Females dissected directly after their appearance on potatoes contained mature eggs, while those examined previous to this date did not. Our earliest record for egg deposition under cage conditions was June 6, while few were laid after July 26. Thus with the overwintered females the oviposition period extended from June 6 to July 26, a period of fifty days.

Attempts were made to secure oviposition on early potatoes by females of the first generation in late July. The cages used were large glass globes placed over plants that had been cut down and allowed to sprout again. These plants were all vigorous and growing at that time. Practically no eggs were obtained, showing that these females were not ovipositing.

The first cage record of eggs of the summer generation adults was on July 11. Under field conditions hatching had become general July 23, showing that the above date was probably correct. Field counts also showed that the period of greatest egg deposition extended between August 6 and 24. A few nymphs were still hatching from the vines as late as October 3, so it is probable that oviposition of the summer generation extended throughout September, since these nymphs could not have been from second brood adults, as shown later. The average number laid a day was practically the same as with the overwintered generation, one fertile egg a day being the general rule under cage conditions.

ATTEMPTS TO REAR A THIRD GENERATION

Attempts were made to get second generation females to oviposit but without success. All adults in this experiment were obtained by rearing nymphs that were known to belong to the fall generation. Owing to the nature of the cages used the mortality was high in this experiment. Second brood females, however, also failed to lay eggs in the large lantern globe cages used as checks. In these cages a much larger percentage of hoppers lived and were alive when last examined, November 8. This generation thus passes the winter without becoming sexually mature. They appear again, as stated, late in May and feed promiscuously for a week or so before the spring flight and oviposition take place.

INCUBATION PERIOD

Under field conditions the incubation period extended from ten to fifteen days, with an average of fourteen. In the insectary, where the temperature averaged nine degrees higher than outside, the egg stage lasted from four to ten days for the first generation and four to twelve days for the second. An average of about seven days was noted for both broods under these conditions.

TABLE II. INCUBATION PERIOD IN THE FIELD

Eggs laid	Average date hatched	Average incubation period	Average incubation for broods
June 3.....	June 17	14 days	first, 13 days
July 12.....	July 23	11 "	
July 14.....	July 26	12 "	
Aug. 2.....	Aug. 12	10 "	second, 11 days
Aug. 15.....	Aug. 27	12 "	
and Sept. 29.....	Sept. 8	10 "	

TABLE III. INCUBATION PERIOD IN THE INSECTARY

Brood	Number of records	Minimum	Maximum	Average
1.....	109	4 days	10 days	7½ days
2.....	31	4 days	12 days	7 days

The greatest number of nymphs hatched during the morning, before the heat of the day. Certain conditions of temperature and humidity greatly influenced this, for hatching occurred at the same time throughout the whole field. During July this period generally came between 8.30 and 9.30 a. m., but later in September, not until after 10.

During the height of the egg-laying period, great numbers of nymphs were continually hatching from a plant. Our records, based on carefully made field counts, showed an average of 1,943 nymphs hatched from one plant during a ten weeks' period from July 23 to October 3. During this time the percentage of egg parasitism was relatively high, so that this does not represent the total number of eggs deposited, which must have been considerably greater. This gives an idea of the population of leafhoppers one potato plant may support during a season. The possible number per acre would thus run above ten millions.

These hatching records were obtained by a daily examination of six branches of potato plants and counting and removing the newly-hatched nymphs. This served as an index to the appearance and abundance of second generation young. August 6 hatching of second generation eggs was already taking place. This continued until frost in October, although at this time very few were found on the plants. It was noted that the greatest number of nymphs hatched out from August 20 to September 6, and that September 11 the number of nymphs hatching was greatly reduced.

LENGTH OF NYMPHAL LIFE

The average length of time spent in the nymphal stages for the first two was two days, for the third and fourth, three, and for the last,

TABLE IV. COMPARATIVE LENGTH OF NYMPHAL INSTARS

Stage	Number of insects observed	Minimum	Maximum	Average
1.....	30	2	3	2
2.....	32	1	4	2
3.....	31	1	5	3
4.....	28	1	6	3
5.....	33	3	8	4
Total.....	154	8	26	14

four. A minimum length of time between molts was one day, as noted for the second, third, or fourth instars, during July, while a maximum of eight days' duration for the fifth was observed during October.

The duration of the nymphal or larval period varied greatly during the different months. In July the insect spent only a week maturing while in September and October, due to cool weather, the nymphal stage was prolonged to twenty-six days. This gave a minimum of fourteen days during July as the cycle from egg deposition to adult and a maximum in September and October of forty days. Thus the total life cycle was ten weeks for the first and over a year for the second generation.

CONTROL OF THE POTATO LEAFHOPPER (*EMPOASCA MALI* LE B.) AND PREVENTION OF "HOPPERBURN"¹

By JOHN E. DUDLEY, JR., *Scientific Assistant, Bureau of Entomology, U. S. Department of Agriculture*

INTRODUCTION

Although periodic outbreaks of a leafhopper, probably the potato leafhopper (*Empoasca mali*), have occurred in this country since the early eighties, the insect's association with a disease of potato has just been established by Ball.²

As with most insect borne diseases it is the disease which we dread far more than the primary feeding injury of the insect involved.

The summer of 1919 was a most opportune time to undertake studies of disease transmission and control of the potato leafhopper. The infestation and accompanying disease had been severe in 1918, promising to be equally as bad the next year. Evidence that a disease formerly included in the term "tip burn" was transmitted by the insect had just appeared. Therefore, the problem was attacked in earnest and all possible data secured on the study of the insect itself, its relation to various hosts, and the effect of treatments used against it. Special emphasis was placed on the phase of most economic importance—transmission of disease and control.

DISEASE TRANSMISSION

The first outward indication of the disease, "hopperburn" (Plate 9), is a slight yellowing, usually at the tip of a leaf, followed by curling

¹ Published by permission of the Secretary of Agriculture.

² Ball, E. D., "The Potato Leafhopper and the Hopperburn That It Causes," in *Wis. State Dept. of Agric. Bul. No. 20, 1918.*



Leaf of Green Mountain potato plants, showing typical brown curled tip and margin ($\times 20$)

and browning. This curling and browning preceded by a diseased, yellow area may spread from the tip or margin inward, eventually reaching the midrib when the leaf dies. The lower two-thirds of the midrib with a narrow green area on either side is the last to be killed, often remaining green for weeks after the spread of the disease to the entire plant.

In hot dry weather the disease usually spreads rapidly and whole fields of early potatoes have been killed in a week's time. On the other hand, if the weather is cool and moist, or if protective sprays have been applied, the disease may be checked and throughout the summer show nothing more than its early symptoms.

The potato leafhopper visits many plants but appears to reproduce on but few; potato, bean (string, pole, navy), hemp, apple, dahlia and hollyhock. A diseased condition with similar symptoms to the disease on potato has been found on the above plants, and on raspberry and box elder.

LABORATORY EXPERIMENTS

Laboratory experiments were conducted to study the effect of leafhopper adults and nymphs upon their several hosts, in relation to transmission of disease. It was found that in nearly all tests adults readily transmitted a disease. Nymphs did not transmit it in as large a proportion of tests as did adults. One adult or one nymph often sufficed to cause a plant to show decided symptoms of disease.

In one test four newly-hatched nymphs were placed on one of two healthy apple seedlings growing in a flower pot. In ten days the infested apple had become badly diseased, the uninfested one remaining green. In another test twenty newly-hatched nymphs were placed on a large healthy dahlia plant. Disease appeared in seven days, the plant dying in twenty days. A check plant remained healthy. These two are typical of many other tests.

FIELD OBSERVATIONS

During visits to potato growing sections of Wisconsin it was observed that, without exception when the disease was present the potato leafhopper was found; that when the disease was not present no leafhoppers were found. The extent of the disease as affecting both individual plants and whole fields was in close proportion to the number of leafhoppers present. An example is given: A field of Green Mountain potatoes on new land surrounded by woods had never been sprayed and, at first glance appeared uninfested by insects. Upon examining the field in detail, however, a leaf here and there was found showing a typically diseased tip. Without exception a leafhopper or cast skin could be found on or near every leaf thus affected.

VARIETAL PREFERENCE OF LEAFHOPPER OR VARIETAL SUSCEPTIBILITY TO DISEASE OR BOTH

Different varieties of potatoes were attacked to different degrees by the potato leafhopper, and different varieties were affected to different degrees by the disease. The extent to which the same varieties were affected appeared to be much the same at widely separated points in the state. The Early Triumph variety was always affected worst; the Rural New Yorker variety always least and, moreover, in a given place, the Rurals were always attacked least by the leafhopper. The relative infestation on other varieties varied considerably.

It is believed that the leafhopper exhibits a preference for certain varieties of potatoes of tender foliage and that these same varieties may be more susceptible to disease than sturdier varieties of hardier foliage.

PLANTS OF A GIVEN VARIETY VARY GREATLY IN AMOUNT OF DISEASE

Observations the past season have shown that certain plants of one variety may have much greater resistance to disease than adjacent plants of the same variety. In a check (unsprayed) plot of Rural New Yorker potatoes three plants remained practically free of disease all summer, while the surrounding plants without exception became badly diseased. The same was true of a plot of Green Mountains.

EFFECT OF THE DISEASE ON THE TUBER

There are indications that the disease transmitted by the potato leafhopper seriously affects the potato tuber. Whether the actual organism of the disease gains entrance into the tuber, or the diseased foliage decreases the value of the tuber for seed, is yet to be determined.

It can be stated, however, that plants of the same variety but from different seed, growing side by side, exhibited decided and uniform difference in the amount of disease present. This difference was noted in two instances at one farm; two fields of Green Mountains were planted in blocks, each block being the seed from a different grower. All potatoes in each field were planted the same date. The degree to which plants in adjoining blocks were affected with disease enabled one to separate the blocks without looking at the end stakes.

In one field at Madison six varieties of potatoes were planted. Seed of five of the varieties came from reputable seedmen, and the plants treated with Bordeaux mixture stood off the disease throughout the summer. The sixth variety, Early Triumph, was seed from plants which had been killed by the disease the year before (1918). The plants from this seed were all killed by the disease early in the season despite thorough treatments with Bordeaux.

Is it possible that some condition due to disease may be carried over

winter in the seed potato, making it easily susceptible to disease when planted the following year?

CONTROL

All spraying was done with a wheelbarrow sprayer, the spray rod fitted with two adjustable arms and two adjustable, angled nozzles. All applications were directed upward at an average pressure of 150 pounds, the material thus being deposited on the under side of the leaves as is absolutely necessary.

KEROSENE EMULSION. One plot of Early Ohio and Green Mountain potatoes was sprayed three times with 10 percentage kerosene emulsion.

The infestation of adults was not noticeably reduced. Nymphs present at the time of spraying were readily killed, but great numbers continued to hatch and did not appear to be killed by any oil remaining on the leaves. There was no repellent effect observed upon adults or nymphs.

The Early Ohios were practically dead from disease by the last week in July. The Green Mountains were badly diseased by the middle of August.

The untreated rows of each variety were but little more diseased than those treated.

NICOTINE SULFATE. One plot of Early Ohio and Rural New Yorker potatoes was sprayed four times with nicotine sulfate 1-1200 and fish oil soap 2-50.

The treatments did not noticeably reduce the infestation of adults; eggs continued to be laid and young nymphs appeared without cessation. Nymphs present when the spray was applied were readily killed but no repellent effect was observed later upon either adults or nymphs.

Disease appeared in this plot a few days after the first spraying. On the Early Ohios the disease spread slowly but surely, until the first week in August, when all plants were practically dead. One row left untreated was at this time diseased to no greater extent than the treated rows.

The Rural New Yorkers, although as heavily infested all summer as the other potatoes, remained fairly free of disease. By the middle of August, however, the disease began to spread and in a week about half of each plant was dead. The untreated row was slightly more diseased than the treated one.

BORDEAUX MIXTURE. One plot of Rural New Yorker and Green Mountain potatoes was sprayed four times with Bordeaux mixture 4-4-50. The infestation of adults and nymphs in this plot was about the same as in the previous plots up until the middle of July. From

then to the end of the summer, however, there was a remarkable scarcity of both, especially on the Rurals. Newly hatched nymphs appeared every day but, strange as it may seem, disappeared in a short time. This repellent effect of Bordeaux has previously been mentioned by Fluke.¹

Untreated rows of each variety in this plot were heavily infested with adults and nymphs throughout the summer.

Disease appeared after the second spraying on tips of leaves scattered all over the plot. No nymphs had hatched at this time. On the Rurals the disease remained without spreading to any extent until digging time. On the Green Mountains the disease spread very slowly and at digging time had not become serious, that is, probably not more than one-fourth of any plant had dead leaves.

On the untreated rows the disease spread without interruption from tip, to margin, to midrib, and all over the plants. At digging time Rurals showed some disease on every leaf; Green Mountains were badly diseased, many plants being dead.

BORDEAUX MIXTURE AND NICOTINE SULFATE. Two adjacent plots of equal size were planted to six varieties of potatoes—Early Triumph, Early Ohio, Irish Cobbler, Green Mountain, Late Puritan and Rural New Yorker. One plot was given maximum protection with five applications of Bordeaux 4-4-50, combined for the two last treatments with nicotine sulfate 1-1200. The other plot received no protection against the leafhopper.

A very heavy infestation and frequent rains seemed at the time to demand five sprayings if maximum protection was to be afforded. It is probable, however, that four applications would have been sufficient.

During the early summer leafhopper adults and nymphs were present in about the same numbers as on other plots, but by the middle of July there was a great scarcity of both. A week later practically no nymphs and only an occasional adult could be found on the sprayed plots. This condition held up to digging time.

The unsprayed plot was at all times rather heavily infested with both adults and nymphs, the numbers increasing as the season advanced.

The treated plot immediately adjacent to a continual source of leafhopper infestation remained in excellent condition throughout the summer, the Early Triumphs being the one exception. (The seed of these came from plants killed by the disease the year before as previously mentioned). A slight amount of disease appeared on the

¹ Fluke, C. L., Jr., "Does Bordeaux Mixture Repel the Potato Leafhopper?" *Jour. Eco. Ent.*, Vol. 12, No. 3, 1919.

other varieties early in the season, showing principally on the tips of scattered leaves. Little more appeared and that present did not spread noticeably all summer, even during a period of hot dry weather. On Late Puritans and Rurals there was almost no disease; on the rest it was very light to light.

The untreated plot showed signs of disease early but, in contrast to the treated plot, the disease spread rapidly until midsummer when early varieties were about dead and the late ones were rather badly diseased. The Rurals, as in other plots, showed less disease at digging time than any other variety.

Thus the plot given maximum protection, in contrast to the plot given no protection, gave abundant evidence throughout the summer of the beneficial effect of spraying in relation to leafhopper infestation and the resultant disease.

YIELDS

The accompanying table shows the relative yields from each plot. No attempt was made to compare the yield from these plots with the average yield per acre in the state because the area around Madison is not adapted to potato growing and because fertilizers were not used on the plots. Yields from untreated plots were arbitrarily called 100 bushels.

TABLE SHOWING YIELDS

	Untreated rows	Treated rows
	Bu. per acre	Bu. per acre
Kerosene Emulsion Plot:		
Early Ohio.....	100	166
Green Mountain.....	100	125
Average.....	100	146.5
Nicotine Sulfate Plot:		
Early Ohio.....	100	150
Rural New Yorker.....	100	200
Average.....	100	175
Bordeaux Mixture Plot:		
Rural New Yorker.....	100	200
Green Mountain.....	100	196
Average.....	100	198
Bordeaux-Nicotine Plot:		
Early Triumph.....	100 ¹	100 ¹
Early Ohio.....	100	196
Irish Cobbler.....	100	277
Green Mountain.....	100	233
Late Puritan.....	100	217
Rural New Yorker.....	100	185
Average.....	100	221.6

¹ Practically no marketable potatoes. Not included in average.

It is seen from the table that the treated rows gave much higher yields, ranging from one-fourth higher with Green Mountains, sprayed with kerosene emulsion, to two and three-fourths times as high with Irish Cobblers, sprayed with Bordeaux-nicotine.

However, as the four plots were widely separated and varied as to soil and previous manuring, the relative yields are not as indicative of the best spray as was the amount of disease which existed on the foliage.

Rural New Yorkers showed less difference in yield from three kinds of treatment than any other variety. They were also diseased less than any other kind. That it payed to spray them, however, is clear.

NUMBER OF APPLICATIONS NECESSARY

It is believed that at least three applications, and preferably four, should be made. The first should be applied when leafhoppers have come in numbers.

The second spray should be applied in from ten days to two weeks from the first. Potato plants are growing rapidly at this time, offering new foliage to leafhopper attack. Frequent rains may be expected in some sections of the country, and will wash off much of the material.

The third spray should usually be applied about two weeks after the second, the exact time depending upon the amount of new growth infested, abundance of leafhoppers, weather conditions. (Hot dry weather is very favorable to rapid spread of the disease.)

A fourth spray might well be given to advantage when some of the following conditions exist: a hot dry summer, heavy new growth in late summer, great abundance of leafhoppers, desire to control certain other potato diseases.

When leaf-eating insects occur with the potato leafhopper, an arsenical can usually be combined with one or more of the Bordeaux sprays.

ENEMIES

Two enemies of the potato leafhopper were in evidence during the past season. One, a hymenopterous parasite, probably a Dryinid, attacked leafhopper eggs. It occurred in too small numbers to be of practical benefit.

The other enemy, a fungus (*Entomophthora sphaerosperma*), attacked both adults and nymphs. It was common all over the state and in northern sections greatly reduced the infestation.

CONCLUSIONS

Of three materials tested by themselves, Bordeaux gave by far the best results in leafhopper control and disease prevention. The yield

from this plot was greater than the next nearest plot by an average of twenty-three bushels.

Bordeaux combined with nicotine gave better results, as would be expected, than Bordeaux used alone. From the excellent results secured with Bordeaux used alone, however, it is doubtful if a combination will be necessary in the future.

The yield from the Bordeaux-nicotine plot would indicate that this combination controlled the insect and disease much better than did Bordeaux used alone. However, the former plot was on rich, recently manured ground, while the latter plot was on poor ground.

From a standpoint of prevention of disease on the foliage, the two treatments appeared of equal value.

INJURIES TO BEANS IN THE POD BY HEMIPTEROUS INSECTS¹

By I. M. HAWLEY, *Ithaca, N. Y.*

During the past four years many samples of beans have been received at the Cornell Station, that have showed deformations varying from circular depressed areas with a dark spot in the center, to ragged holes in which the bean coat is badly ruptured. The name of "dimples" has been applied to these scars. As these markings bear a strong resemblance to Hemipterous punctures on other plants, specimens of *Adelphocorus rapidus* Say, one of the most common Mirids in western New York bean fields, were caged over a potted bean plant on August 15, 1918. When examined on September 4, the pods on this plant were mis-shapen and covered with dark, raised wart-like areas (Pl. 10, fig. 2). The seed in these pods showed evidence of dimpling (Pl. 10, figs. 1 and 3).

In the summer of 1919 an effort was made to verify this observation and to find other insects that might have a share in the work. On August 11, a cage containing *A. rapidus* was placed over two bean plants, the pods of which were still green. When these were examined on August 28, most of the beans were dimpled. One hundred pods picked near the cage contained only one dimpled seed.

The feeding of *A. rapidus* frequently produces such ragged, discolored marks on the bean seed, that it would seem that the insect in addition to removing juices from the bean, possibly secretes a toxin that acts on the bean tissues. The nature of the puncture appears to be influenced by the stage of development of the bean at the time of attack. The

¹Contribution from the Entomological Laboratory of Cornell University.

seed is stunted when punctured and the growth around the injured portion produces the dimple. Beans on plants whose pods are still green, though nearly mature, tend to suffer most.

In the summer of 1918 immature beans in the field were pricked through the pod with a small insect pin and the plants marked by a tag. At harvest time the seed in these pods was dimpled, but in most cases the pits were more regular in outline than in the case of insect punctures (Pl. 10, fig. 3).

It is not always easy to pick out pods which contain dimpled beans by their outward appearance. The pods may be free of the roughened brown areas and still contain abnormal beans. Some have been found where a dark green spot on the lighter green of the pod was the only evidence of the deformation within.

Other insects that produce pits in beans are the spined tobacco bug (*Euschistus variolarius* Palisot de Beauvois) of the family Pentatomidæ and the tarnished plant bug (*Lygus pratensis* L.). Specimens of the first mentioned insect placed with beans on August 19 had produced small pits by September 8 (Pl. 10, fig. 1). Nymphs and adults of the tarnished plant bug left with a plant for nineteen days also produced small dimples (Pl. 10, fig. 1). The work of the latter was previously reported by G. C. Davis from Michigan in 1897. During late summer both of the above insects together with the apple leafhopper (*Empoasca mali* LeBaron) have been found in the field with their beaks inserted in the pods. Cage experiments seem to show however, that the beaks of the leafhoppers are too short to penetrate the pod and injure the beans within. Injury is especially noticed in places where ragweed and lambs quarters are allowed to grow.

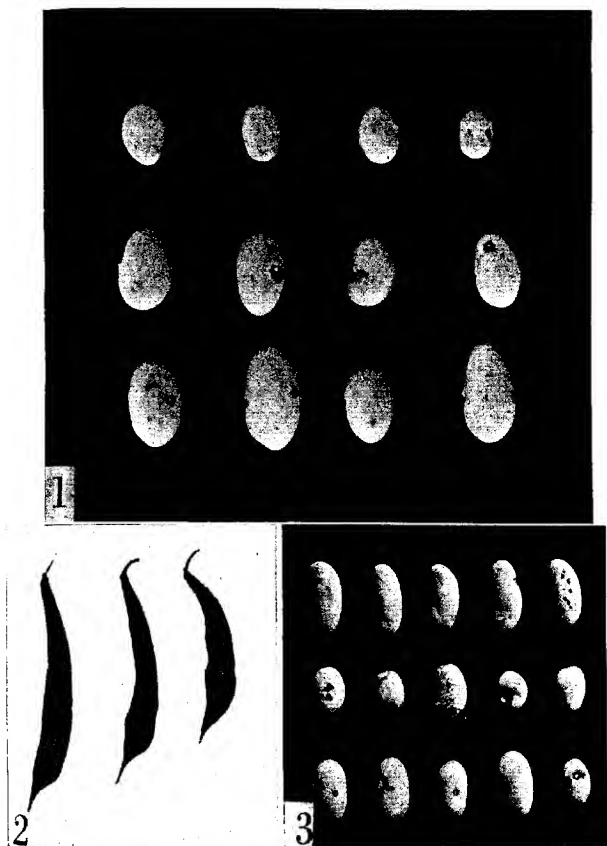
The extent of the damage caused by these pests is not great, but each year there are some beans of this kind in the product of many fields and gardens. The most disfigured of field beans will be discarded with the diseased and immature seed, when they are picked in the warehouse. Small pits might be easily over-looked, but beans with the ragged scars often resulting from the feeding of *A. rapidus* would surely be discarded.

THE SQUASH BUG¹

By F. M. WADLEY, U. S. Bureau of Entomology

The common squash bug, which is a well-known enemy of squashes and pumpkins, is said to be found practically everywhere in the United States, and in Mexico, Central America and Canada. The

¹ *Anasa tristis* De Geer, Family Coreidæ, Order Hemiptera.



1. Beans showing punctures of Hemipterous insects—upper row by *Euschistus variolarius*; middle row by *Adelphocorus rapidus*; lower row by *Lygus pratensis*.
2. Bean pods punctured many times by *Adelphocorus rapidus*.
3. Dimpled or punctured beans. The beans in the lower row were pricked in the pod by an insect pin while still green.

work on which this article is based was done by the writer while in the service of the Federal Bureau of Entomology at Wichita, Kans., late in 1916 and in 1917 and 1918; and at Muscatine, Iowa, in 1919.¹

IMPORTANCE

Both adults and young, especially the latter, injure the plant by sucking its juices, and probably also by the toxic effects of their bites. Small brown spots mark the feeding places of nymphs on the leaves. Further feeding causes large leaf areas to assume a grayish discoloration and die. If the bugs are abundant enough, the whole plant wilts rather suddenly after the death of several leaves. Young seedlings succumb very quickly to squash bug attacks, but since the bugs are scarce early in the season this injury is slight. It is in late summer, when the weather is hot and dry, and squash bug nymphs numerous, that the worst injury occurs. After the vines are killed, bugs are found clustered on squash or pumpkin fruits sucking their juices. If its normal food plants are overcrowded or exhausted, the squash bug may attack other nearby cucurbits, but it is a serious enemy only to squashes and pumpkins. The quick growing summer squashes are especially favored.

DESCRIPTION

The adult is dark brown in general coloration. This effect is given by a yellow ground color, more or less densely dotted with black punctures; variations in density of punctures result in mottling. The antennae, and the membrane of the wing, are solid black. The dorsal surface of the abdomen covered by the wings, is crimson. Adults vary in length from 13 to 16½ mm. and in width from 4½ to 6 mm., averaging 15 and 5 mm. respectively. The female is slightly larger than the male. The newly hatched nymph has a bright green body with red head, thorax and appendages; but within an hour or so the red has changed to black and the green has deepened. These colors remain during the first instar, after which the nymphs are usually gray with black head and appendages. For a short time after each molt, the bug is green with red head and appendages. The nymph has an abdomen large in proportion to the rest of the body, giving a pear-shaped appearance. The wing pads are conspicuous in the later instars. Both nymphs and adults are characterized by a strong sickening odor, common among Heteroptera.

The egg is whitish when first deposited but soon becomes a metallic shining brown. It is about 1½ mm. in length and a modified oval in

¹ During 1918 some of the work was done, under the writer's direction, by Mr. F. M. Liggett. Some of the data on hibernation were taken from the notes of the late Mr. H. O. Marsh.

TABLE I.—SIZES OF NYMPHS IN DIFFERENT INSTARS

Stage	Length of antennae	Beginning of instar		End of instar		(The greatest width is about the middle of the abdomen)
		Length	Width	Length	Width	
1	2	2½ mm.	1½ mm.	.....	.....
2	3	3 mm.	1½ mm.	4 mm.	2 mm.	
3	4	5 mm.	2 mm.	.....	.....
4	4.5 to 5	8 mm.	3½ mm.	9½ mm.	4½ mm.	
5	4 to 7	9.5-10	4 to 5 mm.	13-14.5	7 mm.	

shape. Viewed from either side or the bottom it has a round triangular outline, being compressed from these three directions.

DEVELOPMENT

ADULTS. Those bugs which pass the winter live as adults for nine to twelve months, while others may die the same season they are hatched, after an adult life of a few weeks. The adults fly readily and strongly in the spring when finding food plants, and in the fall when seeking winter quarters. Through the active season they seldom fly, but remain close to the food plants, feeding, mating and ovipositing. They are inactive at night or in cool cloudy weather.

The squash bug has a reproductive period of several weeks; one female having deposited eggs for slightly over two months. Reproductive activities are limited to warm weather with temperatures of 60° F. or over. Reproduction begins under favorable conditions five or six days after the bugs become adult, and continue until death or cool weather. A number of females have deposited an average of ten eggs a day throughout the reproductive period. The eggs are placed in clusters of a few to forty-five, averaging fifteen, usually on the under side of squash or pumpkin leaves, and sometimes on the upper side or on nearby objects. Each egg is glued firmly to the leaf. In 1918, 92 per cent of all eggs were deposited between 8 a. m. and 5 p. m.

EGG. The egg stage at Wichita varies from seven to nine days in hot weather, while egg periods of from ten to seventeen days are recorded for cooler weather early and late in the season. Chittenden records the egg stage at Washington, D. C., as from eight to thirteen days, and Weed and Conradi state that in New Hampshire it varies from six to fifteen days.

NYMPHS. Nymphs are very gregarious and are greedy feeders. The smaller nymphs are found in bands on the under side of the leaves, while the larger nymphs frequent the stems, as do the adults. The nymphs scatter when their food plants die, but can probably not go far before succumbing to hunger. Pot cages were relied on for data on length of instars in individuals, while large numbers of nymphs

were reared in cloth-covered cages in the garden for total nymphal life. The periods in pot cage rearing are perhaps a little longer than normal, as the nymphs did not thrive as well as in the larger cages. Dr. Chittenden has found nymphal instars at Washington to require 3, 8 or 9, 7 or 8, 6, and 8 days respectively, totalling 33 days. Weed and Conradi report that the instars require 3, 9, 8, 7 and 9 days respectively, with a total of 36 days, in New Hampshire. The figures secured at Wichita are given in Table II below.

TABLE II.—LENGTH OF INSTARS

Stage	July and early Aug., hot weather			Late Aug. and Sept., cool, nights chilly		
	Number specimens	Average length	Variation	Number specimens	Average length	Variation
1st.....	14	2.14 days	2 to 3 days	5	5.2 days	4 to 7 days
2nd.....	10	6.2 days	4 to 8 days	4	9.25 days	8 to 11 days
3rd.....	4	8.1 days	6 to 11 days	1	13 days	.....
4th.....	(1)	(14)	.....	2	10 days	9 to 11 days
5th.....	..	..	..	1	12 days	.....
Total.....	..	30.44	26 to 36 days	..	49.45 days	46 to 56 days
Cloth covered cages.....	..	28 to 30	22 to 34 days	..	.....	.....

One nymph reared in hot weather required fourteen days for the fourth and fifth stages combined, the fourth molt being overlooked. It can be seen that these two stages must cover fourteen days or less in summer if the length of the first three instars combined is compared with their average nymphal life. In October, with frosty nights, one nymph required twenty days for the fourth instar while another in the fifth instar lived seventeen days without molting.

SEASONAL HISTORY

The squash bug in southern Kansas has, besides the first summer generation, a large, but not complete second generation, and a small third generation. In east central Iowa there is a small second generation but no third. The bugs increase rapidly during the active season, but this is short owing to their temperature requirements. There is probably a large or small second generation throughout the corn belt, and in the South three or more generations may be expected. The common statement that but one generation develops seems based on the work of Weed and Conradi in New Hampshire, which was accurate, but not representative for most of the country. Slingerland, Gillette, Sirrine, Smith and Garcia, have stated as their belief that more than one generation develops.

OVER-WINTERED GENERATION. Only adults survive the winter in most of the United States, though it seems likely, from the temperature nymphs endure in the fall, that they might winter successfully

in the extreme South. General activity begins with the first warm summer weather early in June. While some bugs die early, most of them live until about August 1 or later. In 1918 one female lived until August 28. Egg production continues with little diminution until death. In 1917 over-wintered females deposited on the average 502.5 eggs each; in 1918, 419. In the latter case totals were reduced by the escape of several females early in the season, daily averages for 1918 giving a seasonal total of 634 eggs per female. These average totals exclude the few which died early in the season.

TABLE III.—AVERAGE EGG-PRODUCTION OF OVER-WINTERED FEMALES

Period	Eggs per female per day	
	1917	1918
May 30—June 15.....	No figures	2.5
June 16—June 30.....	9.9	10.3
July 1—15.....	13.1	11.9
July 16—31.....	9.1	8.5
Aug. 1—15.....	12.1	3.6
Aug. 16—18.....	6.0	...
Aug. 16—27.....	...	7.1
Average for period June 16— Aug. 18.....	10.4	9.0

TABLE IV.—EGGS PRODUCED IN EACH MONTH, PER CENT OF TOTAL

Month	1917	1918
May.....	0	1.4
June.....	24.3	30.8
July.....	63.4	54.2
Aug.....	12.3	13.6

SUMMER GENERATIONS. The earliest of the first generation mature in July and the latest some time in October. In 1917 two females deposited an average of 356 eggs each before death late in August, averaging 9.6 eggs per female per day. Those maturing later produced fewer eggs, but about 80 per cent of the first summer generation became adult before September 1, or in time to produce some eggs.

The nymphs of the second generation are very numerous in late summer. The earliest of them become adult about August 20 at Wichita, and produce a few eggs. In 1918 four females of this generation produced a total of 335 eggs before ceasing; and averaged 8.4 eggs per female per day, from August 25 to September 3. Later individuals become adult throughout the fall and many perish from cold before maturing. The nymphs of the third generation are present at Wichita during the fall. Most of them probably perish before maturity. None have been known to mature, although one was reared to the fifth stage by October 5.

FALL ACTIVITIES. The first cool nights about September 1 check activities. Bugs maturing after this neither copulate nor oviposit. Those already producing show a marked checking of reproductive activities, which cease within about two weeks. From the few individuals studied, it seems that the adults of the first generation which have produced many eggs, die before fall; but those adults which have pro-

duced only a few eggs, so far as is known, live and go into hibernation. Early in September adults begin scattering to seek hibernation quarters, while younger stages develop slowly on account of the increasing coolness. After the food plants are killed by frost many starve, while others collect on the fruits. Some nymphs mature and adults are usually present among the nymphs all fall. These adults, however, keep scattering. All remaining nymphs are finally killed by the cold. In 1917 a temperature of 14° F. killed all nymphs. The bugs are last seen in their summer haunts some time in November.

HIbernation. When dispersing, squash bugs reach all sorts of locations, such as buildings, tree trunks, brush and others. They have been found hibernating under boards, under a weed pile, and in bark crevices on the under side of a log. From a few to over fifty have been found hibernating in one location. Various workers mention hibernation in sheds, under boards, in wood piles, and among stones. At Wichita adults of the first, second and perhaps third generations may hibernate to appear again as the overwintered generation.

The shaded blocks in the diagram show the time of year a given stage is present while the dotted lines indicate the time it is not present.

TABLE V.—CALENDAR OF OCCURRENCE

	1917 (Kansas)	1918 (Kansas)	1919 (Iowa)
First adult seen	May 10	May 23	.....
First eggs seen		May 30	.....
Eggs abundant in field	June 20	June 15	.....
First nymphs hatched		June 13	.....
Adults first generation reared	July 12	July 6	July 28
Eggs from first generation	July 18	July 14	Aug. 4
First nymphs second generation	July 27	July 23	Aug. 17
First adults of second generation	Aug. 20	Aug. 19	Sept. 19
Eggs from second generation		Aug. 25	.....
Nymphs of third generation hatched	Early Sept.	Early Sept.	.....
Over-wintered females died	June 22, 23, 25, July 26, 31, Aug. 13, 18	June 19, July 20, Aug. 19, 28	.....
Last eggs deposited in cages	Sept. 13	Sept. 11	Sept. 3
Last adult and nymphs seen in field	Nov. 20		

TABLE VI.—DIAGRAM SHOWING STAGES PRESENT AT A GIVEN TIME

[illegible]

NATURAL CHECKS

Chittenden, Girault, and Weed and Conradi mention parasites of the egg and adult, a bacterial disease, and cannibalism as checks on the squash bug. These do not appear to be active under Kansas conditions, the principal checks on the species being lack of food and cold. Cool weather restricts activities, and all nymphs and many adults perish from winter cold. All the plants in a patch are sometimes killed by the bugs in late summer. Adults may fly to other feeding places, but nymphs must perish in thousands, before finding food. Where bugs have cut off their own food supply in this manner, they will usually not assume normal numbers in the locality until late the next year. Many nymphs starve in the fall after frosts kill their food-plants.

CONTROL

GENERAL CONSIDERATIONS.—Control of the species is difficult when bugs are numerous, but it is not impossible. The methods found effective include cultural or preventive measures, and hand-picking and spraying, which are remedial measures. Other methods which have been advocated at times but not found practical, include the use of coverings for young plants, planting an excess of seed, fumigation under covers, the use of repellents, and burning bugs in the fall with a torch.

Cultural measures are valuable in restricting injury by squash bugs, other insects, and plant diseases, and will usually increase the crop even if no enemies are present. They should be used in all cases as far as possible. When squash bugs are present in injurious numbers, and the crop is of considerable value, remedial measures may also be employed. Hand-picking must be depended on in small garden plots, and may supplement spraying in larger gardens. Spraying is expensive, and is not warranted unless the crop is profitable, and the attack severe. It may be of value in large home gardens, or market gardens. Where squashes and pumpkins are grown on an extensive plan, and large returns are not expected, remedial measures cannot be profitable, but cultural measures should usually insure a fair crop.

CULTURAL METHODS.—These include crop rotation, fertilization and thorough tillage, and clean farming in the fall. The first method aims at removing the crop from the vicinity where the bugs have developed the preceding season, and where observation shows that their work begins earliest and is most severe. It is efficient in large fields. The second method aims at stimulating plant growth so as to give a good yield in spite of some injury. Clean fall culture is very important, as the fruits left on the ground nourish many bugs

that would otherwise perish, and encourage hibernation in the vicinity. All fruits should be gathered early, the vines cleaned up, field thoroughly plowed, and brushy and weedy borders cleaned up. Neglect of such measures will greatly increase the number of bugs in the vicinity the following season, as observation has shown.

HAND PICKING.—The plan is to prevent development of squash bugs by removing all adults and eggs from the plant early in the season. The method is very laborious and will not altogether prevent injury; but if carried on throughout the season a fair crop can be secured in spite of the bugs.

TEST OF CONTACT INSECTICIDES.—In the fall of 1916, squash bugs were dipped in various contact insecticides to give an idea as to their efficiency. The more effective insecticides were then tested out in the field, by spraying a small area on which bugs were congregated, and confining them on it with a screen cone. The bugs were given a chance to dry, and kept twenty-four hours under favorable conditions, as determined by a check, when the living and dead were counted. The results are given in Table VII.

TABLE VII

Solution used	Laboratory		Field	
	No. bugs used	Per cent killed	No. bugs used	Per cent killed
Fish-oil soap, 0.4 to 0.5 pounds per gallon	40	75	47	70
Same, plus "Black Leaf 40," 1 to 1,000	20	95	68	66
Same, plus "Black Leaf 40," 1 to 500	20	90	..	..
Same, plus "Black Leaf 40," 1 to 250	20	100	121	83.5
Same, plus sulphur, 1 or 2 ounces per gallon	40	97.5	168	91.70
Fish-oil soap, 0.2 pounds per gallon	30	60	..	..
Same, plus "Black Leaf 40," 1 to 1,000	20	95	61	57
Same, plus "Black Leaf 40," 1 to 250	20	85	..	..
Same, plus sulphur, 1 or 2 ounces per gallon	10	60	..	..

These figures are for adults, the solutions used all being deadly to nymphs. A strong soap solution with sulphur in suspension has given the best results of any spray yet tested against the squash bug. Nicotine sulphate is less effective in the field, though promising in laboratory tests. The sulphur makes trouble by clogging nozzles and settling, but its advantages more than offset these drawbacks. Tests in 1917 confirmed these data, and also showed that nymphs succumbed to fish-oil soap at 0.2 pounds per gallon, sometimes to even weaker solutions; that sulphur much increased the effectiveness of the soap against nymphs as well as adults; that sulphur paste alone will not harm squash bugs; that strong soap solutions will not affect the eggs; and that squash plants suffer little or no injury from fish-oil soap solutions

of the strengths used. A soda-sulphur compound, made up like lime-sulphur, was tested, but seemed unpromising.

In 1917 a small plot of squashes, severely infested with bugs, was sprayed July 18 and again August 2. Fish-oil soap, 0.2 pounds per gallon, without sulphur, was used. The infestation was checked, the plants recovered and bore a good crop; however, the bugs reached injurious numbers again in September. In 1918, one-sixth acre of squash and pumpkins was sprayed during the last week in July, using soap, 0.25 pounds per gallon, and sulphur, 2 ounces per gallon. The infestation was moderately severe and was causing some injury. The spraying was a complete success, no second application being necessary, and bugs were very scarce the rest of the season.

SPRAYING.—We would recommend fish-oil soap, 0.25 pounds per gallon, with sulphur, as an efficient spray. The soap is hard to obtain in many places, but may usually be ordered from distributing centers. A good hand sprayer, with extension rod and angle nozzle, has given good results. A larger sprayer might be arranged for this work, but a man must handle each spray rod, as little could be done with fixed nozzles. Care must be taken to keep the sulphur suspended. Spraying should be postponed until nymphs are numerous and severe injury seems threatened. If it can be avoided altogether, and a good yield secured, so much the better. If the grower sprays in early or mid-summer, the bugs are almost sure to assume injurious numbers again before fall. In Southern Kansas, if spraying can be postponed until July 25 or later, injury will usually be eliminated for the rest of the season. Some adults and all eggs will escape the spray. Adults and eggs are scarcest late in July, when many over-wintered adults have died, and few of the first generation have matured. A coarse driving spray should be used, spraying first under the leaves, then on the larger stems. Wherever groups of bugs are found they should be thoroughly drenched, lifting stems and fruits if necessary, and directing the spray against bugs on the ground as they leave the plants. The bugs surviving will scatter, and re-assemble in a few days. If these are numerous, and if many eggs were present, a second spray ten days later may be desirable. This will take less time and material than the first, as the groups of bugs will be much fewer. The expense of such spraying is considerable. In experiments it has required one man about thirty hours to spray an acre, and the thorough application necessary will require 300 to 400 gallons per acre. Under 1918 conditions, the cost of spraying an acre was about \$25; under 1914 conditions it would be about \$15. It should be kept in mind that a patch of squashes or pumpkins grown intensively usually occupies only a fraction of an acre.

BIBLIOGRAPHY

The following papers contain data or statements on the squash bug:

1. CRITTENDEN, F. H. 1899. Some Insects Injurious to Garden and Orchard Crops. U. S. Dept. Agr., Div. Ent., Bul. 19, n. s. 28 (see pp. 20).
2. 1908. The Common Squash Bug. U. S. Dept. Agr., Div. Ent., Circ. 39 (2nd revise).
3. GARCIA, F. 1908. Injurious Insects. N. Mex. Bul. 68.
4. GARMAN, H. 1901. Enemies of Cucumbers and Related Plants. Ky. Bul. 91.
5. GILLETTE, C. P. 1898. Colorado's Worst Insect Pests and Their Remedies. Colo. Bul. 47.
6. GIRAULT, A. A. 1904. *Anasa tristis* DeG.; History of Confined Adults; Another Egg-Parasite. Ent. News, '04; pp. 335-336.
7. GRIFFIN, H. H. 1897. Results of Experiments at the San Juan Substation. N. Mex. Bul. 21.
8. HARRIS, T. W. 1862. Insects Injurious to Vegetation (see pp. 194-197).
9. LUGGER, O. 1900. Bugs Injurious to Our Cultivated Plants. Minn. Bul. 69.
10. QUAINANCE, A. L. 1899. Some Important Insect Enemies of Cucurbits. Fla. Bul. 30.
11. SIRRINE, F. A. 1894. Some Insects Injurious to Squash, Melon, and Cucumber Vines. N. Y. (Geneva) Bul. 75.
12. SLINGERLAND, M. V. 1895. A Talk About Squash Bugs. Rural New Yorker, July 13, 1895.
13. SMITH, J. B. 1893. Insects Injurious to Cucurbs. N. J. Bul. 94.
14. SMITH, R. I. 1908. Some Insect Enemies of Garden-Crops. N. C. Bul. 197.
- 15.—1910. Insect Enemies of Cantaloupe, Cucumber, and Related Plants. N. C. Bul. 205.
16. SURFACE, H. A. 1902. Insects Injurious to Cucurbitaceous Plants. Penna. Dept. Agr., Bul. 96.
17. WEED, C. M. and CONRADI, A. F. 1902. The Squash Bug. N. H. Bul. 89.

BROOM CORN, THE PROBABLE HOST IN WHICH PYRAUSTA NUBILALIS HUBN. REACHED AMERICA

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Since the introduction of the European corn borer, *Pyrausta nubilalis* Hubn., into America, there has been a very considerable interest as to the manner in which this insect may have reached the eastern shores of the United States. Most of the published statements have indicated raw hemp imported from southern or central Europe as the possible food plant in which the European corn borer obtained entrance into this country.

At a public hearing held by the Federal Horticultural Board at Boston, Mass., August 15, 1919, Professor George G. Atwood, chief nursery inspector for the state of New York, made the following statement:

"This is a good time to give the theory we have. We believe that you had the corn borer here in Massachusetts two years, perhaps, before we. We think there were no corn borers in the state of New York previous to seven or eight years ago, probably ten. We do know that about eight years ago broom corn was imported from Austria and taken into the city of Amsterdam where it was manufactured into brooms, and the waste from the factory was thrown out, given away and scattered along the Mohawk River. Now, the prevailing winds are mostly from the West. Scouting so far has revealed about ten miles west of the city of Amsterdam in a narrow valley of the Mohawk River the presence of corn borer but very slightly, but ten miles going down from Amsterdam to Mohawk for a distance of ten miles there is a strip about a mile wide on both sides of the river down to the city of Scotia. My theory is that waste from the infested section in Amsterdam was distributed either by the northwesterly winds or with the floods. We had floods that covered hundreds of acres just west of Schenectady. That is where we have the thickest part of our infestation. We fully believe that the introduction of broom corn at Amsterdam was responsible for the presence of the insect. As far as the spread of the insect in New York is concerned we have been unable to find anything east of the Hudson River."

As a result of Mr. Atwood's statement, the records of importation of broom corn were looked up. The following data showing the amounts and the origin of the broom corn imported into the United States for the years 1909 to 1918, inclusive, have been compiled from the report of the Bureau of Foreign and Domestic Commerce, Department of Commerce:

<i>Year</i>	<i>Country</i>	<i>Tons</i>
1909.....	Austria-Hungary	1,097
	Germany	601
	Italy	181
1910.....	Austria-Hungary	3,007
	Belgium	2
	England	1
	France	1,574
	Germany	67
	Italy	2,213
	The Netherlands	90
	Russia in Europe	53
1911.....	Turkey in Europe	382
	Austria-Hungary	425
	Belgium	9
	Germany	52
	Italy	89
	Roumania	21
	Russia in Europe	7
	Turkey in Europe	13

Year	Country	Tons
1912.....	Austria-Hungary	646
	France	6
	Germany	10
	Italy	609
	Roumania	39
	Russia in Europe	28
1913.....	Austria-Hungary	67
	Italy	9
	Russia in Europe	2
1914.....	Austria-Hungary	537
	England	24
	Germany	104
	Italy	573
1915.....	Austria-Hungary	103
	Italy	1
1916.....	Italy	158
1917.....	France	\$3.00 worth
1918.....	Italy	374
Total.....		13,174 tons

These facts seemed so significant that it became desirable to determine, if possible, the distribution of the thousands of tons of broom corn brought into this country during the previous nine or ten years, as indicated in the report of the Department of Commerce, and the writer was detailed to investigate the matter. The results of this investigation are given below. It will be recalled that the first record of the presence of *Pyrausta nubilalis* in America was from specimens reared from dahlia stems collected at Everett, Mass., during the summer of 1916. It seems significant that the point of collection of this infested material was but a short distance from two broom manufacturing concerns located in that city.

During the winter of 1909-10 the Lee Broom & Duster Company¹ at Everett, Mass., received 183,000 pounds of Austro-Hungarian broom corn shipped direct from Budapest, Hungary. Two shipments of a total of 92,000 pounds were landed at the Mystic Wharves, Chelsea, Mass., and a third shipment of 91,000 pounds was landed in New York and trans-shipped to Boston via the Merchants' S. S. Line. During the period December 1, 1911, to January 24, 1912, a shipment of 120,009 pounds of Italian broom corn was received from Florence, Italy. From December 26, 1911, to January 2, 1912, a total of 1,054 bales of Austro-Hungarian broom corn shipped from Budapest was received at New York and transferred via water to Boston, thence to the Everett factory. Up to January 1, 1916, there still remained in

¹ The author is greatly indebted to Mr. Thomas H. Marsland who has furnished much information and many details of the broom corn situation during 1909 to 1914.

storage eighty bales of Austro-Hungarian broom corn from the 1911 importation, and a part of this broom corn was not used at Everett until some time after July 1, 1916.

Subsequent investigations continued in New York City made it possible to interview Mr. Wilson M. Toll, one of the largest jobbers and importers of foreign broom corn in the United States. During the season of 1909 the broom corn crop in this country was very short, and as a result of this condition Mr. Toll, early in the fall of 1909, left for Budapest, Hungary, for the purpose of importing large quantities of the Austro-Hungarian crop into America. He purchased 1,000 tons of the 1909 Hungarian crop which was received in New York City during the winter of 1909-10. Upon receipt of this shipment at least two-thirds of the importation immediately was forwarded to the factories at Amsterdam, N. Y. A large shipment was made to Frankfort, Ky., and smaller shipments to Louisville, Ky., Rochester and Buffalo, N. Y., and other points. Mr. Toll also advised that at this time Canadian buyers purchased considerable amounts of Hungarian broom corn which went to Hamilton, Ontario, to be used by the large broom factories at that point.

During March, 1910, Mr. Toll imported 3,000 bales of the 1909 crop of Italian broom corn which was shipped direct from Venice to New York. This was disposed of to various factories of which no definite record is available.

On September 23, 1919, Mr. M. Dorn of the Frankfort Broom Company of Frankfort, Ky., was interviewed and stated that "between May 11, 1909, and June 16, 1909, he received, from New York a shipment of 528,888 pounds of Austro-Hungarian broom corn all of which probably was manufactured into brooms within three months after receipt." Mr. Dorn was the first to import Hungarian broom corn into America, which original importation was made in the fall of 1899, when 400 tons were imported for use at the Frankfort factory and a Mr. Gross of Chicago imported 150 tons for use in that city. Mr. Dorn adds that "all of the broom corn in this importation of 550 tons was of the Hungarian crop previous to 1899 and that to his knowledge none of it was of the Hungarian grown crop of that year, and for this reason would not be apt to have been infested with the European corn borer."

Information relative to the Hungarian broom corn shipped to Louisville could not be obtained.

Amongst others of the American importers of broom corn who visited Budapest during the fall of 1909 was Mr. M. K. Kavanaugh of the Kavanaugh Bros. Broom Corn Company of Chicago, Ill., who imported 600 tons. This lot of broom corn was landed at New York

and Newport News, Va. Of this 600-ton importation more than 2,775 bales were received in Chicago between February 23 and March 2, 1910, whence it was sold in job lots as follows: 80 per cent of same to the some thirty manufacturing plants located in Chicago and its suburbs, and the remainder to establishments in Indianapolis, Ind., Milwaukee, Wis., Dubuque, Iowa, Toronto, Ontario, Montreal, Quebec, and numerous other points in the United States of which no definite record was obtainable.

It is apparent from the foregoing statement that the shipments of broom corn, which thus far it has been possible to trace, account for not more than one-third of the total tonnage of broom corn imported into the United States since 1909, as shown in the report of the Department of Commerce, and that the states to which it was shipped are as follows: Massachusetts, New York, Kentucky, Illinois, Indiana, Wisconsin, and Iowa.

Foreign literature dealing with *Pyrausta nubilalis* Hubn. apparently does not make specific note of this insect as being a serious enemy of broom corn in southern and central Europe, although it is well known as a serious pest of maize in that country. However, since it is known to infest broom corn under field conditions in Massachusetts and has fed voraciously upon that plant in the laboratory, it no doubt infests broom corn as grown in Austria-Hungary.

Our investigations to date made in the United States at a great many of the points where Hungarian broom corn is known to have been received for manufacture have failed to discover its presence except in the vicinity of Boston, Mass., Amsterdam, and Buffalo, N. Y. Hence, it seems a very significant fact that the three existing infested areas in Massachusetts and New York, as originally located, were in each instance within reasonably short distances of broom factories. In so far as the hemp theory is concerned, it will be recalled that it was based on the fact that the first located infestation in Massachusetts was not far from the Charlestown Navy Yard where considerable amounts of raw hemp are used in the manufacture of rope. At the same time, however, importations originating from identical sources were being made at Plymouth, Mass., some forty miles south, and at Andover, Mass., approximately twenty-five miles north of Charlestown, and yet no infestations of the European corn borer in the vicinity of either of the two latter places were discovered until the summer of 1919. This situation gives rise to a very considerable doubt as to the validity of the hemp theory in its relation to the original Massachusetts infestation, and would appear to indicate the greater possibility of broom corn used at the Everett factory as being the vehicle in which the pest reached this country. Assuming that the broom corn im-

ported from Austria-Hungary was infested when it reached America, there would seem to have been ample opportunity for the adults to escape because much of the material remained in storage and was not manufactured until some time after the normal dates of spring emergence under our climatic conditions.

The fact that this insect is not now known to be established in any of the other numerous points in America where Austro-Hungarian broom corn was shipped may be due to several causes, one of which is an incomplete survey of the suspected regions. Thus, the data obtained upon this phase of the European corn borer situation to date appear to indicate rather forcibly that broom corn was the vehicle in which the European corn borer reached America.

BEAN LADYBIRD

By W. E. HINDS, *Entomologist Alabama Experiment Station*

For many years the bean ladybird, *Epilachna corrupta* Muls., has been known to occur in Arizona, New Mexico, Colorado, and to a very limited extent in some adjacent states, where serious damage has been done to all varieties of table beans. The injury to the crop has been frequently very severe, but the spread of the pest has seemed to be slow and but little damage was done in the Plains region. Under the climatic conditions in that territory, two generations occurred and control measures consisted principally in jarring the insect from the plant to the hot, dry ground. Insecticidal measures gave little relief and appeared to act mainly as a repellent rather than insecticide.

No occurrence of this insect East of the Mississippi River was known to us until specimens of the pest were received at the Alabama Experiment Station in July, 1920, from Jefferson and Bibb Counties, Alabama. Since that time a number of reports indicate its occurrence through a considerable area and scouting work conducted about the 20th of August revealed the fact that the pest has been present in the vicinity of Blocton, Ala., in Bibb County, where it was first noticed in July, 1918. The first appearance of the pest in Jefferson County seems to have been within the city limits of Birmingham in July, 1919. During that season many truckers lost their late crop of beans but made no report of the occurrence of an insect pest to the Experiment Station or to any person realizing the danger of this insect becoming established.

At the present time the pest occurs throughout Jefferson County and extends into adjacent counties, particularly southwestward to Bibb County. The second generation is now becoming adult during the latter part of August and the insect is likely to continue its spread

considerably before the end of the season. We have no information as to the limit of flight.

An important new food plant record is found in the occurrence of the beetle in all stages upon cowpeas in one locality. It remains to be seen whether cowpeas will constitute a favorable food plant. The growth of cowpeas and soy beans is quite extensive in this section of Alabama and large truck farmers around Birmingham are deeply interested in the production of all varieties of table beans. The problem appears, therefore, a serious one for this section and it is possible that the insect may spread widely throughout the southeastern states. It has demonstrated its ability to withstand ordinary climatic, winter conditions in north central Alabama and has flourished under our summer climatic conditions. The further spread of the pest will be watched closely and an investigation of life history and field control has already been started.

It would appear that the introduction of this pest had occurred in commercial shipments, either of alfalfa hay or of beans and possibly with both materials produced in the infested territory in Arizona, New Mexico and Colorado. The possibility of exterminating the pest would appear to be slight at this time, and methods of control will, therefore, be sought as rapidly as possible.

Scientific Notes

The European Corn Borer in Canada. On August 10, the European corn borer was discovered for the first time in Canada. Larvæ about half an inch in length were found on that date near Lorraine Station, Welland County, Ontario, by Messrs. Keenan and Simpson of the Division of Foreign Pests Suppression. The infestation at this point was light but more eastward, particularly in the vicinity of Ridgeway and Chrystal Beach, Ont., the infestation was heavier. Larvæ collected at these three points were determined by Dr. J. H. McDunnough, chief of the Division of Systematic Entomology, as *Pyrausta nubilalis*, and this determination has since been confirmed by Mr. D. J. Caffrey, in charge of the European Corn Borer Laboratory, Arlington, Mass.

Since these first infestations were discovered, Mr. L. S. McLaine, chief of the Division of Foreign Pests Suppression, has undertaken much further scouting in other parts of Ontario and this work is still under way. From present knowledge Mr. McLaine has given me the following statement:

"When the borer was discovered at Ridgeway and Chrystal Beach an effort was made to find the limits of the infestation. According to latest advices this extends from Fort Erie on the east to Dunnville on the west along the Lake Erie shore and about twenty miles inland. On August 23, larvæ were received from a farmer, living near St. Thomas, Ont. Scouts were immediately despatched to this new infestation and their first report indicated that 5 per cent of the corn plants in the fields examined were infested. The infestation in western Ontario has not as yet been defined, but on September 16 it composed all of Elgin and Middlesex counties and a portion of Oxford County."

On the above date (September 16) an important conference took place at St. Thomas, Ont., at which the following men were present: Messrs. W. R. Walton and L. H. Worthley, of the United States Bureau of Entomology; Dr. E. P. Felt, state entomologist of New York; Dr. J. H. Grisdale, deputy minister, Dominion Department of Agriculture; Prof. L. Caesar, provincial entomologist, Ontario, and Messrs. Gibson, McLaine, Keenan and Vroom of the Dominion Entomological Service. Fields of field corn in the vicinity of St. Thomas were investigated, some of which were very seriously infested, in one field probably a commercial loss of from 20 to 25 per cent had resulted.

ARTHUR GIBSON

Acting Dominion Entomologist, Department of Agriculture,
Ottawa, Canada

The Green Japanese Beetle (*Popillia japonica*), which was discovered in New Jersey several years ago and which has been confined to that state, is now known to occur in Pennsylvania along the Delaware River for a distance of nearly eight miles and extending back from the river one-fourth to one and one-half miles. The Pennsylvania infestation was first discovered in July, 1920, by Mr. Fred Worsinger, a scout for the Pennsylvania State Department of Agriculture. Beetles were first found in Pennsylvania at Torresdale and here the beetles are most abundant and that location is apparently the center of the Pennsylvania infestation.

The conditions in Pennsylvania are apparently ideal for the beetle and there is reason to believe that it will increase and spread at the same rate as in New Jersey.

Just how the beetle became established in Pennsylvania is problematical. The supposed center of infestation is at Torresdale and up the river from the nearest known 1919 infestation in New Jersey. It is not, therefore, likely that the beetle flew across the river. A club house in New Jersey within the infested area affords considerable traffic across the river, particularly during the summer months when the beetles are active. Weeds and rubbish are sometimes carried up the river with the tide from the New Jersey shore to the Pennsylvania side. Either of these last two possibilities are likely methods of transportation.

Although some scouting was done in Pennsylvania in 1919, there is little doubt that a few beetles occurred on that side of the river a year ago.

JOHN J. DAVIS.

Riverton, N. J., Sept. 2, 1920.

Round-Headed Apple Tree Borer Injuring Apple Fruits. On July 20th, while inspecting an orchard near Scotland, Pa., the writer observed a considerable number of large feeding scars on apple fruits. At first it was somewhat puzzling to state the real cause of the damage, but after a more thorough search the real culprit was found to be the adults of *Saperda candida*.

These feeding punctures were frequently 5 to 10 mm. in width, 10 to 20 mm. in length and 1 to 2 mm. in depth. In some instances the fruit was marked by trough-like gouges 4 mm. in width and 8 to 10 mm. in length. The work of this beetle may be determined by the rather large serrate margins of the feeding scars, this being caused by the sharp, pointed mandibles. Not infrequently the surface of the fruit bears string-like frass particles, 3 to 6 mm. in length.

The amount of feeding in this orchard was considerable as most of the tree trunks were badly infested with borers.

Under laboratory conditions the adult beetles caused injury to fruits similar to the injury observed in the field thus proving conclusively that the adult borer was re-

sponsible. It was also noted that the beetles when confined exclusively with apple fruits oviposited in them.

J. L. KING.

Chambersburg Laboratory,
Pennsylvania Bureau of Plant Industry.

Flea-Beetle Injury to Apples. A species of flea-beetle, identified as *Nodonota puncticollis* Say, has caused considerable injury in a few apple orchards in the vicinity of Chambersburg, Pa., during the season of 1920.

The beetle was first noticed on the apple foliage in a weedy orchard on the 2nd of June. At that time slight feeding injuries were observed on the leaves but none on the fruits. On the 14th of June, however, the writer received a hurry call to visit an orchard where "bugs were eating up the apples" and found upon entering the orchard that the report was not greatly exaggerated and that the flea-beetle was responsible for the damage.

The injury was mostly superficial, the skin of the apples being chewed away in places and then small shallow pits eaten out of the flesh. In many cases, however, rather large cavities were eaten in the apples and especially so where apples were in contact with each other. Feeding injury was also noted on the leaves and in a few places the leaves were brown in color due to the many small areas of leaf surface which had been eaten away.

To prove whether the injury to the fruits was primary or followed some other insect injury or abrasion the writer caged specimens of the beetle with perfect apples and found that while the beetles preferred to begin feeding where the skin was broken, they were not deterred by perfect fruits.

Flea-beetle injury was noted subsequently in a number of orchards but in only the one orchard was it thought serious enough to require a controlling spray of Bordeaux mixture and arsenate of lead. As for the effects of the spray it was impossible to judge definitely due to the lateness of the application. In all cases, orchards showing injury were more or less neglected and weedy. During the remainder of June numbers of the beetles were observed on most of the common weeds along the roadsides and in the fields.

J. R. STEAR.

Chambersburg Laboratory,
Pennsylvania Bureau of Plant Industry.

PRENATAE, the Entomological Club of the University of Minnesota holds regular meetings every Tuesday, throughout the year, at 4.30 p. m. in the entomological laboratories, University Farm, St. Paul. During the summer special field trips will be arranged. Any entomologists visiting the Twin Cities are invited to attend and to take part in these meetings. Among the visitors and speakers of the past year have been—H. E. Ewing of the National Museum; W. E. Dove, Bureau of Entomology; T. B. McGath, Mayo Institute; H. E. Strickland, Canadian Entomological Service; Professor H. L. Osborn, Hamline University, and Professor Sadao Yoshida, Osaka, Japan. Dr. B. P. Lawson of the Entomological Department, University of Kansas will give the course in Elementary Economic Entomology in the summer school of the University of Minnesota. This work will be offered from June 21 to July 30. More specialized courses will be offered for various members of the department not only during the period of the regular session, but throughout the summer.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

JUNE, 1920

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photoengravings may be obtained by authors at cost. The receipt of all papers will be acknowledged.—Eds.

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The recent discovery of large areas with a gipsy moth infestation of some years' standing and a similar find in relation to the European corn borer raises a series of interesting questions. Those familiar with the subject may recall that the gipsy moth maintained itself in this country practically unnoticed for twenty-two years, and the evidence at hand indicates that the European corn borer was probably introduced some ten years before its recognition. Furthermore, these records are by no means peculiar to these two insects or to certain infestations by one or both. The facts are that outbreaks by unknown insects largely escape attention unless of marked severity and even then may not be brought to official attention with desirable promptitude. This is due to two causes. It is frequently very difficult to decide in advance the true status of an importation, and in not a few instances the observer, if there be one, is unable to distinguish between an unusually abundant native species and a newcomer. The assistant farm bureau agents, working in some counties of New York state, will render material assistance along these lines since they give special attention to insect pests and plant diseases. County farm bureau agents are extremely valuable in the early detection of new insect pests. There should be, however, wider appreciation of the important part played by insects and this can be brought about only by more general knowledge of the group, not so much along systematic lines as in popular and practical ways. The general public should appreciate more fully the economic status of the group and come to have a sympathetic appreciation of the part played by the hexapoda in the scheme of nature. Not all are willing to become entomologists and it is not

advisable that they should. It is entirely possible for a very large proportion of our people to cultivate an appreciation of the various manifestations of nature and through such understanding put themselves in a position to more readily detect the unusual. This is especially desirable among agriculturists, though it should by no means be limited to one class. Attention is called to this matter because it is believed that all such agencies can and should be utilized in keeping watch upon the varied activities of insects, and in doing this we are engaged in one line of economic entomology.

Current Notes

Conducted by the Associate Editor

The Wolley-Dod Collection of Lepidoptera has been bequeathed to the Entomological Branch and arrived in Ottawa on June 23.

Doctor A. B. Cordley has retired as director of the Oregon Agricultural Experiment Station, but continues as dean of the School of Agriculture.

Mr. J. A. Flock, junior entomologist at the Strathroy Laboratory, Dominion of Canada, resigned on August 4 to go into commercial work.

The old insectary at Cornell University, built by Professor Comstock in 1886, has been torn down to make room for the new chemistry building.

Professor H. A. Gossard, Agricultural Experiment Station, Wooster, Ohio, spent his vacation in an automobile trip through northern Illinois and parts of Iowa.

Thousands of acres of hardwood forest land have been stripped by forest tent caterpillars in New Brunswick, the greatest damage occurring in the vicinity of Moncton.

Apanteles lacteicolor was again recovered from brown-tail winter webs collected in Nova Scotia. This recovery is quite gratifying as only a few nests of this pest were found last winter.

Mr. E. P. Felt, state entomologist of New York, was presented September 14, with a traveling bag by his associates on the State Museum staff in recognition of twenty-five years of service.

Mr. P. R. Lowry, a graduate of the Ohio State University, who was employed temporarily as assistant in the entomological department of the Ohio station in 1917, is again assisting the same department for the summer.

Professor R. D. Watt of the School of Agriculture, The University, Sydney, Australia, visited the Entomological Branch, Ottawa, Canada, the latter part of July and reported on the meetings of the Imperial Entomological Conference held in London, England, last June.

The Canadian Forest Insect Field laboratory has been moved from Fort Coulonge and will be placed near Queen's Park, Aylmer, P. Q., in a suitable location. The bark beetle control work in British Columbia is practically completed for this season. Mr. Hopping is now supervising the final work including burning the slash from the winter's cutting operations. Mr. Dunn has taken charge of a party on the spruce budworm survey in New Brunswick. Messrs. McFarlane and Crosbie recently ap-

pointed to temporary positions in this division, have been transferred to New Brunswick and are attached to the spruce budworm survey parties.

A very severe outbreak of potato beetles was reported from Manitoba and the wheat stem sawfly has appeared in large numbers in certain districts of Canada during the past season.

Doctor Swaine and Mr. Fleming left Ottawa July 4 for an inspection of the spruce and balsam conditions on the timber limits of the Abitibi Pulp and Paper Company in the vicinity of Lake Abitibi, northern Ontario. They also intend to select sites for the establishing of sample plots in that district.

Mr. A. E. Kellett, artist and chief photographer of the Entomological Branch, Ottawa, Canada, since 1913, resigned on July 31. Mr. Kellett's resignation will be regretted by all members of the staff. He plans to go to London, England, early in the fall to study at one of the well-known art schools.

Doctor A. G. Boving and Doctor F. C. Craighead left Washington on June 25 for Harrisburg, Pa., to consult with Professor J. G. Sanders, economic zoologist, and to study the coleopterous larvæ in the State Museum. The state of Pennsylvania is publishing Doctor Craighead's large illustrated paper on cerambycid larvæ.

Mr. John J. Davis, in charge of the Japanese beetle work at Riverton, N. J., has accepted the position as head of the Department of Entomology at Purdue University, Lafayette, Ind., and will report for duty October 1. Mr. C. H. Hadley, who has been connected with the work, will succeed Mr. Davis in charge of the Japanese beetle work at Riverton, N. J.

Professor T. D. A. Cockerell of the University of Colorado spent the last two weeks in June assisting S. A. Rohwer to arrange the National Collection of bees. This was a very large task to complete in so short a time, but by unusual effort the entire named collection has been arranged in one series and a small part of the unworked material identified.

The maximum flight of the European corn borer in eastern Massachusetts began June 12, which is about ten days later than in 1918 and 1919. Eggs of the insect were found in abundance on various plants June 15, and a remarkable departure from the habits of the insect in former years was observed in the deposition of many egg clusters on spinach, beets, and other cultivated plants.

Doctor J. H. McDunnough returned from his collecting trips to the Lake of Bays, Ontario, the latter part of July. Special attention was paid to the Odonata, and since his return Doctor McDunnough has been working over the material in the National Collection. As a result of his trips several new records have been established for Ontario and at least two for Canada. Officers in charge of laboratories wishing to have their Odonata identified should send in their material as soon as possible.

A reorganization of the Division of Entomology at the University of California has been announced, taking effect July 1 of this year. The personnel of the division consists of eight members and will hereafter be known as the Division of Entomology and Parasitology, with Professor W. B. Herms as newly appointed head. Professor Herms will continue his activities in the field of parasitology, particularly medical entomology and ecology, while Professor C. W. Woodworth will devote his time largely if not wholly to research. The new organization of the division embraces three groups with assistant Professor E. C. Van Dyke as chairman in supervision of activities in general entomology and taxonomy; Assistant Professor Essig, chairman in supervision of agricultural entomology, and Assistant Professor S. B. Free-

born, supervising activities in parasitology, particularly in relation to the animal industries. Doctor H. H. Severin will continue investigating *Euleltiz tenella* in relation to sugar beet blight, while Messrs. E. R. de Ong and G. A. Coleman will continue their activities in their respective fields, namely University Farm School and apiculture respectively.

The following appointments have been made in the Entomological Branch, Canadian Department of Agriculture: Mr. F. P. Ide, temporary laboratory helper, Division of Systematic Entomology; Mr. H. G. Hammond, temporary seasonal assistant, Division of Field Crop and Garden Insects at Ottawa; Mr. R. S. Hawkins, Mr. A. H. MacAndrews, temporary seasonal assistants, Spruce Budworm Survey, Fredericton, N. B.; Mr. R. S. Longley, insect pests inspector, Division of Foreign Insect Pest Suppression, Wolfville, N. S.; Miss M. G. Runciman, temporary junior clerk stenographer, at Annapolis, N. S.

Announcement has been made of the following resignations from the Bureau of Entomology: Jacob Kotinsky, to enter commercial work; H. K. Plank to accept a position as entomologist of the new Agricultural Experiment Station, Guayaquil, Ecuador; D. F. Barnes, C. B. Russell, F. S. Vidler, gipsy moth work, to enter business, and Doctor R. W. Glaser, of the same force, to accept a position with the Rockefeller Institute of Medical Research; H. W. Allen, Arlington, Mass., to accept a position with the State of Mississippi; A. L. Ford, West Lafayette, Ind., to become entomologist for South Dakota; F. B. Herbert, Los Gatos, Calif.; Ada F. Kucala, Washington, D. C.; Everett E. Wehr, Dallas, Tex., to re-enter college; T. H. Cutrer, Baton Rouge, La., to enter commercial work; Thomas H. Jones, to become state entomologist of Louisiana.

The following transfers are announced in the Bureau of Entomology: John B. Gil, Monticello, Fla., to Brownwood, Tex.; Samuel Blum, Columbia, S. C., to West Lafayette, Ind.; Max Kisluk, Jr., Wilmington, N. C., to Federal Horticultural Board, El Paso, Tex.; J. G. Hester, Kingsville, Tex., to Federal Horticultural Board, El Paso, Tex.; R. A. Vickery, San Antonio, Tex., and A. H. Beyer, Wichita, Kan., to corn borer work, Boston, Mass.; C. H. Gable, Tempe, Ariz., in charge of station, San Antonio, Tex.; H. P. Wood, Dallas, Tex., to Arlington, Mass.; J. N. Tenhet, Quincy, Fla., to Clarksville, Tenn.; L. Z. Taylor, from boll weevil force to the Insecticide and Fungicide Board; W. M. Davidson, Alhambra, Calif., to Vienna, Va.; F. J. Brinley, Greeley, Colo., to Riverton, N. J.; Mrs. M. L. Gardner, to Bureau of Biological Survey; George N. Wolcott, Bureau of Plant Industry to Bureau of Entomology; C. W. Stockwell, Melrose Highlands, Mass., to Riverton, N. J., in charge of plant quarantine inspection in connection with the Japanese beetle.

Appointments to the Bureau of Entomology are announced as follows: H. E. Thompson, Riverton, N. J.; Miss Julia E. Edmonson, insect delineator, Washington; Miss Lorena Stratton, Medford, Ore.; W. J. Ahearn, M. H. Feeney, G. J. Galvin, R. W. Kennedy, J. F. Keough, P. Meagher, G. A. Miller, A. C. Ward, W. G. Bradley, J. A. Priest, G. E. Abbott, W. W. Bancroft and S. E. May, gipsy moth work; T. M. Cannon, W. B. Clark, C. O. Larrabee, Boston, Mass.; R. J. Chambers, Arlington, Mass.; Miss Josephine Reed, Wichita, Kans.; Webb B. Williams, boll weevil force; Robert Fouts, Carlisle, Pa.; W. F. Runyen, Riverton, N. J.; cotton-boll weevil, Tallulah, La., F. R. Bibby, M. R. Smith, J. C. Woolley, G. W. Alexander, S. N. Boyd, A. J. Chapman, Joseph Crister, B. M. Deavenport, Clyde Dunn, J. A. Harris, R. T. Hobson, T. H. Holland, J. W. Hollandsworth, E. E. Holley, J. A. Humphries, A. J. Mattox, A. G. McCarty, L. G. Plyer, Wm. D. Reed, Arthur Shaver, Wm. R. Smith, W. A. Stevenson, Adolph Thomas, W. B. Vinzant, R. L. White, V. V. Wil-

liams; Madison, Fla., W. W. Alexander, Paul Calhoun; tobacco insects, Clarksville, Tenn., L. N. Judah, J. T. Lewis, Jr., Scott C. Lion, M. L. MacQueen, T. P. Weakley, sugar cane insects, New Orleans, La., W. E. Haley, Brownsville, Tex., L. R. T. Cowen; miscellaneous insects, Mound La., Charles G. Van Dine.

Doctor R. J. Tillyard, in charge of biology, Cawthron Institute of Scientific Research, Nelson, New Zealand, visited Boston, Philadelphia, Washington, New Haven, Conn., and Amherst, Mass., the latter part of August on his trip around the world. Doctor Tillyard is traveling in the interests of his government and of The Cawthron Institute, and is especially interested in acquiring information about equipment, books and insect pests. The woolly aphid of the apple is one of the important pests in New Zealand. From the Eastern States, Doctor Tillyard will visit British Columbia and return home via Honolulu where he expects to stop for a month.

The following appointments and changes in the Division of Entomology, North Carolina State Department of Agriculture, at Raleigh, are announced: Mr. C. S. Brimley, formerly zoological collector and dealer, and author of many papers on zoological and entomological subjects, is engaged for insect survey work and other projects. Mr. V. R. Haber, from Department of Entomology, University of Minnesota, is to take up household insects and to assist in other projects. Mr. W. B. Mabey, from the Montana Agricultural College, will take up extension entomology in place of M. R. Smith, resigned, and Mr. T. B. Mitchell, from Massachusetts Agricultural College, will take up inspection and field work in place of Mr. J. E. Eckert, resigned. The staff of the Division is now: F. Sherman, chief in entomology; R. W. Leiby, assistant entomologist, investigations; C. S. Brimley, investigations; V. R. Haber, investigations; T. B. Mitchell, inspections and field work; W. B. Mabey, extension; C. L. Sams, beekeeping extension, in co-operation with Bureau of Entomology and Miss Ellen Hinsdale, clerk.

THIRTY-THIRD ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The thirty-third annual meeting of the American Association of Economic Entomologists will be held at the University of Chicago, December 29 to 31, 1920. Notices have already been sent to the members, requesting titles for papers. These must be in the hands of the secretary by November 13, in order to appear on the program.

Applications for membership may be secured from the secretary or from the chairman of the committee on membership. They should be filled out and filed with the chairman of the committee prior to the time of the meeting.

The Chicago meeting will be an important one and promises to be largely attended. In addition to the meetings of the sections on apiculture and horticultural inspection, it is expected that a joint session will be held with the American Phytopathological Society.

A. F. BURGESS, *Secretary*

